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IMPROVING ENGINE COOLING WITH SPECIAL BAFFLES

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NACA

WASHINGTON

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

ADVANCE RESTRICTED REPORT

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SUMMARY

Tests were made to determine the effect of special baffles on the temperatures and the cooling-air requirements of the Wright 1820 G200 and R-2600-8 cylinders. Nine baffle combinations were tested on a Wright 1820 G200 cylinder and two baffle combinations, on a front-row cylinder from a Wright R-2600-8 engine. One special baffle was tested on a front-row cylinder of an R-2600-8 multicylinder engine operating on a torque stand.

Some of the special baffles tested resulted in substantial reductions in cylinder-barrel and rear cylinder-head temperatures. The ducts provided for conducting cold air to the high-temperature regions were very effective in improving the cooling of internal areas that have good thermal connection with the external-cooling means, such as the combustion-chamber walls. Tests with the Wright R-2600-8 cylinder showed that changes in the baffles were not very effective in reducing the temperature of surfaces that tend to be thermally isolated from the external-cooling means, such as the exhaust-valve crown or the spark-plug center electrodes.

INTRODUCTION

The tests herein described were made at the NACA laboratory in Cleveland during 1943 as a result of difficulties experienced in cooling exhaust-valve and rear spark-plug regions of air-cooled aircraft cylinders during high-output cruising operations. A specific object of this investigation was to determine whether an improvement in cooling could be made by changing the cylinder baffling without causing an appreciable increase in total cooling-air flow. The following methods of improving cooling by means of baffles were tested:

1. Increasing the cooling-air mass flow across overheated areas

2. Reducing the cooling-air mass flow through the engine and the baffle wall to a minimum consistent with the cooling required

3. Shortening the cooling-air flow paths through long fin passages by dividing the flow into several shorter paths

4. Conducting cool air to high-temperature regions

Before special baffles can be used as standard equipment, considerable testing must be done over a wide range of operating conditions because the specified maximum external temperatures will no longer be criterions of safe internal temperatures when the new baffles are used. Baffle modifications that lower the temperature of the rear spark-plug boss proportionately more than the critical internal temperatures, such as the spark-plug electrodes and the exhaust-valve crown, may require a low maximum allowable boss temperature. Because of the inappreciable effect of external cooling on the temperature of the exhaust-valve crown, as shown in references 1 and 2, it was believed advisable in these tests to determine the effect of baffle modifications on the cooling of the exhaust-valve crown. Consequently, temperatures of this region were measured in tests of the most promising baffle combination.

APPARATUS AND PROCEDURE

Description of baffles. - The special baffles described in this report were fitted to either a Wright 1820 G200 cylinder or a Wright R-2600-8 front-row cylinder mounted on single-cylinder engines; one special baffle was also tested on a Wright R-2600-8 multicylinder engine. Each baffle tested is described and given an identification number. (See table 1.) The baffle number followed by the letter "S" indicates the manufacturer's standard baffle.

Table 2 lists the combinations of baffles tested and the reason for testing each combination. The identification number designates the baffles making up the combination. The baffles listed in table 2 are shown in figures 1 to 10.

Test installations. --Single-cylinder tests were conducted on two different Cooperative Universal engines. The setups of the 1820 and the 2600 cylinders, shown in figures 11 and 12, respectively, were similar in every respect except for the cooling-air systems. Power was absorbed with electric dynamometers and fuel was supplied by injection into the intake pipes during the induction stroke.

Cooling air was supplied to the 1820 cylinder by a variable-speed centrifugal blower through a pipe of 8-inch diameter connected to a cowling box on the engine. The cooling-air flow was measured with an orifice installed at the entrance of the duct to the centrifugal blower. Cooling-air temperature was controlled by regulating the air temperature in the engine room.

Cooling air for the 2600 cylinder was furnished by a central air system through a duct of 16-inch diameter leading to the cowling box, as shown in figure 12. Deflecting vanes were installed at the front of the 2600 cylinder to simulate the cooling effect of air movements found in multicylinder engines in flight. The position of these vanes was adjusted to give a temperature distribution typical of that obtained when using the standard baffles in flight. The vanes were fixed in this position throughout the tests. A control valve and a heat exchanger were placed in the duct between the orifice and the duct to the cowling box. The cooling-air temperature was controlled by the flow of cold water through the heat exchanger.

Special baffles 46-48-49 were tested and compared with the standard baffles on cylinder 2 of the front row of a Wr Wright R-2600-8 engine equipped with a torque nose and operating on a torque stand. These tests were made with a flight propeller. Cooling air was drawn over the engine by a blower connected to the exit of the engine cowling.

Temperature measurements. - On the single-cylinder engines, cylinder temperatures were measured by thermocouples located as shown in figure 13. The exhaust-valve crown and the spark-plug electrode thermocouples (22, 23, and 24) were used only in some of the tests of baffles 41S-42S-43S and 46-48-49 on the single-cylinder setup of the Wright R-2600-8 front-row cylinder. Only the rear spark-plug-gasket and the rear middle-barrel temperatures were measured in the multicylinder-engine tests.

Iron-constantan thermocouples were used on the head and the barrel. The thermocouples on the head were peened into holes drilled to within approximately 1/8 inch of the combustion chamber. Thermocouples on the barrel were spot-welded to the outside surface of the barrel between fins. The thermocouple in the exhaust rocker-arm bolt was installed on the center line of the bolt at the center of the exhaust rocker-arm bearing. A standard Army type rear spark-plug-gasket thermocouple was used at the rear spark plug.

The method of installing a thermocouple in the exhaust-valve crown was similar to that reported in reference 1. A thermocouple was formed by welding a constantan wire at the end of a stainless-steel tube of 3/32-inch diameter that was inserted through a hole

drilled in the tip of the valve stem. The thermocouple was inserted into a hole drilled to within 1/16 inch of the outside surface of the crown and the valve was sealed with the original amount of sodium.

Chromel-alumel thermocouples were installed in C34S spark plugs in holes drilled in the center electrode to within 1/16 inch of the combustion-chamber end.

<u>Tests</u>. - Each baffle was tested at constant engine power, varying the pressure drop across the cylinder. The following engine conditions were maintained constant during the tests:

	1820 single-cylinder engine	2600 single-cylinder engine 1	[a]2	R-2600-8 multi-cylinder engine
Indicated horsepower	66	78	103	[b]975
Engine speed, rpm	2000	2100	2100	2100
Manifold pressure, inches of mercury absolute	31	31	38	31
Fuel-air ratio	0.083	0.075	0.10	0.075
Inlet-air temperature, °F	250	160	150	100
Spark advance, both spark plugs, degrees B.T.C.	20	20	20	20
Compression ratio	6.76	6.9	6.9	6.9
Cooling-air temperature, °F	100	100	90	95
Oil-in temperature, °F	180	180	180	145
AN-F-28 fuel, performance number	130	130	130	130

[a]Tests in which the temperature of the valve crown and the spark-plug center electrode were measured in addition to those of the other areas.
[b]Multicylinder output in brake horsepower.

In both single-cylinder-engine setups (figs. 11 and 12) the static pressure in the cowling box ahead of the cylinder was determined by a water manometer. The difference between this static pressure in the cowling box and the engine-room pressure was used as the baffle cooling-air pressure drop Δp. Pressure-drop measurements were corrected to standard air density for the air in front of the cylinder by multiplying the measured Δp by σ, the ratio of the density of the air ahead of the cylinder to the standard air density of 0.0765 pound per cubic foot. The pressure drop across the multicylinder engine was measured by impact tubes in front of the cylinders and static tubes in the curl of the baffles at the rear of the cylinders.

Considerable care was exercised in successive setups of the same baffles to insure installation in the same location. Tests were made to determine the effect of small differences in baffle position. Likewise, care was taken to insure that all the cooling air flowed through the passages provided by the baffles and the fins.

The performance of each baffle tested is presented in a plot showing the variation of cylinder temperature minus cooling-air temperature ΔT with baffle cooling-air pressure drop $\sigma\Delta p$. A comparison of the performance of each special baffle with respect to the standard baffle is made by plotting the following relations against $\sigma\Delta p$:

$$\frac{\text{Cylinder temperature - cooling-air temperature (special baffle)}}{\text{Cylinder temperature - cooling-air temperature (standard baffle)}} \times 100$$

and

$$\frac{\text{Cooling-air flow (special baffle)}}{\text{Cooling-air flow (standard baffle)}} \times 100$$

In the figures the foregoing relations are included under the common legend

$$\text{Performance ratio, } \frac{\text{special baffle}}{\text{standard baffle}} \times 100$$

RESULTS AND DISCUSSION

Tests with the 1820 Cylinder

The baffle combinations tested on the 1820 cylinder are illustrated in figure 14 and a comparison of cooling-air flows for these baffles is shown in figure 15.

Effect of baffle mounting. - The exact location and mounting of baffles on cylinders is known to have an appreciable effect upon cylinder cooling. In some cases it is easily possible to fit the baffles in a number of different positions on the cylinder, thus causing a variation of the results obtained. In order to determine the mounting error involved in tests of this nature, the standard baffles 1S-2S-3S were removed, reinstalled, and tested three times. The scatter of the data on these three trials is shown in figure 16. The lines faired through the points for these three tests were used in this investigation as representing the relation between cylinder temperatures and cooling-air pressure drop for the standard baffles for the 1820 cylinder.

The effect of incorrectly locating the standard baffles on the 1820 cylinder is shown in figures 15, 17, and 18. The side baffles 2S and 3S were inadvertently mounted too low on the cylinder barrel, which caused an increase in air-passage area below the lowest fins on the head. An improvement in cooling of more than 14 percent resulted from the change in baffle position. A part of this reduction in temperature can be attributed to a decrease in the temperature rise of the cooling air as the cooling-air flow is increased.

The 14-percent decrease in cylinder temperatures was accompanied by an increase in cooling-air flow of from 18 to 22 percent. Although an engine cowling can generally be redesigned so as to minimize the effects of an increase in flow through the baffle wall on the power required and the pressure difference available, it is evident that, for constant cowl-slot or cowl-flap outlet area, an increase in the flow area under the baffles will decrease the available pressure difference across the baffles. For this reason, the excellence of a baffle must be judged not only in terms of the temperature reductions obtained for the pressure difference used but also in terms of the quantity of cooling air required.

Effects of raising baffles over restricted fin passages. - The results of tests on baffles 10-2S-3S are presented in figures 19 and 20. Baffle 10 was similar to the standard head baffle except that it was fitted closer to the fin tips and the area over the exhaust-port fins was raised to maintain constant flow area. The results show slight percentage increases and decreases in cylinder temperatures. The air-flow quantity was reduced about 4 percent. The exhaust rocker-arm bolt experienced the greatest reduction in ΔT (fig. 20) especially at low cooling-air flows. From these results it is apparent that the fins over the exhaust-valve port are quite effective in cooling the side of the exhaust rocker box but have only a slight effect on the temperature of the exhaust-valve guide. Test results of baffles of this description are also presented in reference 3.

A more direct comparison of the value of increasing the baffle fin-tip clearance over restricted fin areas can be obtained by studying the test results obtained with baffles 1S-6-7-8 and 1S-6-7-9, which are shown in figures 15, 21, 22, 23, and 24. Baffle 8 was fitted close to the fin tips on the side wall of the exhaust port. This finned wall is integral with the valve-guide boss; the valve-guide temperature should therefore respond to any substantial improvement in cooling of this area. Baffle 9 was similar to baffle 8 except that the baffle was raised over the fins to obtain constant flow area. For a cylinder pressure drop of 8 inches,

baffle 9 lowered the exhaust-valve-guide temperature 7° F. Other cylinder-head temperatures were less affected. The raised baffle caused only a slight increase in cooling-air flow.

Baffles for introducing cold air to high-temperature areas. - Baffles 6 and 7, which were designed to bring cold air from the front of the cylinder and cause it to flow over the hot area around the rear spark plug, were tested in combination with baffles 9 and 10, as illustrated in figure 5. The test results are shown in figures 15, 25, and 26 for baffles 10-6-7-9. This combination of baffles resulted in considerably better cooling, especially at the rear of the cylinder, than was obtained with the standard baffles. The improvement was obtained at the expense of from 5- to 8-percent increase in air flow.

The effect of substituting the standard head baffle 1S for baffle 10 in the foregoing combination is shown by comparing figures 24 and 26. The slight decrease in flow with baffles 1S-6-7-9, which is somewhat contradictory to what was previously found in comparing baffles 1S and 10 in combinations 10-2S-3S and 1S-2S-3S (fig. 20), may have been caused by a difference or a change in interference of the air flows at the rear of the cylinder head.

Baffles 1S-4-5-11-12 were constructed to obtain better cooling of the cylinder barrel by dividing the flow on each side of the barrel in two paths and by adding cold air at the sides of the barrel, as shown in figure 6. The results obtained are shown in figures 15, 27, and 28. At a value of $\sigma \Delta p$ of 6 inches of water, the flow was reduced about 14 percent and the barrel temperatures were reduced from 5 to 10 percent. Some improvement in cylinder-head cooling was effected at the lower pressure drops; otherwise the front temperatures increased, as might be expected from the decreased approach velocities resulting from the decreased weight flow of cooling air.

Another method of achieving divided flow around the barrel is illustrated in figure 7 (baffles 1S-4-5-13). In this design, part of the flow is brought to the rear of the barrel and then forward a short distance through the fins where it is discharged. The results obtained with this baffle (figs.15, 29, and 30) indicate a somewhat less favorable over-all performance than was obtained with baffles 1S-4-5-11-12; however, the middle and the top of the cylinder barrel at the rear experienced a reduction in temperature of about 30 percent as compared with 10 percent for baffles 1S-4-5-11-12. Further modifications to baffles 11, 12, and 13 may provide additional improvements in performance.

Tests with sprayed-metal baffles. - Experiments were conducted with cylinder baffles formed by spraying metal directly on the fin tips, as illustrated in figure 8 (baffles 14-15). The sprayed baffles were tested in combination with an air scoop over the head. The results from this baffle combination are shown in figures 15, 31, and 32. A 32-percent reduction in air flow was achieved at a $\sigma\Delta p$ of 6 inches of water. Regions on the cylinder head, such as the exhaust-valve guide, the front spark-plug bushing, the exhaust rocker-arm bolt, and the head between the valves which are materially affected by baffle leakage and approach velocities were increased in temperature. The barrel temperatures indicate that baffles sprayed on the barrel were just as effective as the standard baffles notwithstanding the lower cooling-air flow. The duct leading to the rear spark plug was very effective in reducing the temperature at that point.

Tests with a Front-Row 2600 Cylinder

A number of baffles were tested on the 2600 cylinder that have not been included in this report. The performance of one of the best baffle combinations tested 46-48-49 can be compared in figures 33 to 36 with the standard baffles 41S-42S-43S for this cylinder. The increase in flow through this baffle combination was somewhat excessive, amounting to about 18 percent at a value of $\sigma\Delta p$ of 8 inches of water. Very substantial improvements were obtained, however, in cooling the spark-plug bushing and the rear cylinder barrel. Little change occurred in the temperature of the exhaust-valve guide.

Effect of special baffles on exhaust-valve-crown and spark-plug-electrode temperatures. - Additional tests were conducted to determine the effect of baffles 41S-42S-43S and 46-48-49 on the temperatures of critical areas, such as the exhaust-valve crown and the spark-plug center electrode, which tend to be thermally isolated from the external cooling surface. These tests were conducted at higher power than the previous tests. The results, which are presented in figures 37, 38, and 39, show very appreciable percentage reductions in rear spark-plug-bushing temperatures. The percentage reduction in the temperatures of the exhaust-valve crown and the spark-plug electrodes, however, is relatively small. The relation of $\sigma\Delta p$ and cooling-air flow shown in figure 35 may be applied to the foregoing data inasmuch as power has little effect on this relation.

Tests with the R-2600-8 Multicylinder Engine

Tests were made to compare the standard baffles and the special baffles 46-48-49 to determine whether the improvements observed in single-cylinder tests could be realized with a multicylinder engine.

After the performance of the standard baffles was determined, baffles 46-48-49 were mounted on cylinder 2 and the performance tests were repeated. For comparison, the performance of the standard baffles and the special baffles on cylinder 2 are shown in figure 40. The test results show improvement in cooling of the rear spark-plug gasket and the rear middle barrel.

That less improvement in cooling is shown in the multicylinder tests than in the single-cylinder tests may be attributed largely to the effects of air leaks that exist in the multicylinder-engine baffle wall and the fact that the special baffles were fitted to only one cylinder.

CONCLUDING REMARKS

Internal cylinder surfaces that have good thermal connection with the external-cooling means respond to changes in external cooling. These internal cylinder surfaces are generally associated with a temperature level only slightly above the external temperatures. Such surfaces, which include the combustion-chamber walls and the valve seats, are directly affected by baffle modifications.

Internal cylinder surfaces that tend to be thermally isolated from the external-cooling means are predominately cooled by the incoming charge. These surfaces, which include the exhaust-valve crown and the spark-plug electrodes, are identified by their high operating temperatures. Such surfaces respond poorly to changes in external cooling as caused by baffle modifications.

Of the several methods tested for improving the cooling through special baffles, that of conducting cool air to the high-temperature regions proves most effective. When the quantity of cooling air required is considered, improvements in cooling obtained by increasing the mass cooling-air flow are effective but relatively costly in air requirements.

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2. Cook, Harvey A., Vandeman, Jack E., and Brown, Kenneth D.: Effect of Several Methods of Increasing Knock-Limited Power on Cylinder Temperatures. NACA ARR No. E4I15, 1944.

3. Schey, Oscar W., Rollin, Vern G., and Buckner, Howard A., Jr.: Comparative Cooling of Cylinders of Nonuniform Fin Width with Tight-Fitting Baffles and with Baffles that Provide Constant Flow-Path Areas. NACA ARR No. E4D21, 1944.

TABLE 1. - IDENTIFICATION OF BAFFLES TESTED

Baffle	Cylinder-area covered	Figure illustrating baffle	Description of baffle
Wright R-1820 G200 cylinder			
1S	Top of head	1,3,4,6,7	Standard head baffle
2S	Inlet side of head and barrel	1,2	Standard side baffle
3S	Exhaust side of head and barrel	1,2	Standard side baffle
4	Inlet side of head	6,7	Standard side baffle with barrel portion cut off
5	Exhaust side of head	6,7	Similar to baffle 4
6	Inlet side of head and barrel	3,4,5	Passage concentric with barrel collects air for cooling area under rear spark plug
7	Exhaust side of barrel	3,4,5	Similar to baffle 6
8	Exhaust side of head	3	Contoured for complete contact with exhaust-port fins
9	Exhaust side of head	4,5	Baffle over exhaust-port fins raised from the fin tips to give constant air-passage area
10	Top of head	2,5	In complete contact with head fins except over exhaust-valve area, where constant air-passage area is provided
11	Inlet side of barrel	6	Cooling air taken in at front is rejected at sides and new cooling air is taken in through side scoops for rear portion of barrel. Fin passages are blocked off at air-exchange point.
12	Exhaust side of barrel	6	Similar to baffle 11
13	Rear half of barrel	7	A rectangular duct, concentric with the barrel and in contact with the fin tips, directs air from both sides of the barrel to the fins at the rear. The air entering the fins at the sides and at the rear meet and exit through tubes across the duct.
14	Top of head, exhaust side of head, and both sides of barrel	8	The air is confined in the fin passages by a layer of sprayed metal bonded to the fin tips. Aluminum was sprayed on the head fins and steel sprayed on the barrel fins.
15	Area immediately under rear spark plug	8	An air scoop and duct takes air from the front of the cylinder over the head baffle and to the finned area of the head under the rear spark plug.
Wright R-2600-8 front-row cylinder			
41S	Top of head	9	Standard head baffle
42S	Inlet side of head and barrel	9	Standard side baffle
43S	Exhaust side of head and barrel	9	Standard side baffle
46	Top of head	10	Head baffle with enlarged scoop for directing air into fins above rear spark plug
48	Exhaust side of head and barrel	10	Air duct around barrel for directing air to area under rear spark plug
49	Inlet side of head and barrel	10	Air duct around barrel to direct air to area adjacent to rear spark plug

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TABLE 2. - IDENTIFICATION OF BAFFLE COMBINATIONS TESTED

Baffle combination	Figure illustrating baffle combination	Object of testing
	Wright R-1820 G200 cylinder	
1S-2S-3S	1	To make reference tests of standard baffles for comparison with tests of special baffles
1S-2S-3S	1	To show the effect of incorrectly mounting the standard baffles 2S and 3S
10-2S-3S	2	To study the effect of a close-fitting head baffle except for the area over the exhaust-valve port where the baffle was raised above the fin tips to provide constant air-passage area
1S-6-7-8	3	To determine the effect of a close-fitting baffle over restricted-flow areas for comparison with 1S-6-7-9
1S-6-7-9	4	To show the effect of using a raised baffle over restricted-flow areas
10-6-7-9	5	To test baffle 10 in combination with special cooling ducts around the barrel
1S-4-5-11-12	6	To test the effect of dividing the air flow around the barrel into four paths
1S-4-5-13	7	To cool the barrel at the rear with air from scoops on both sides of the barrel
14-15	8	To determine whether a sprayed metal baffle is practical and whether the bond with the fins would improve the cylinder cooling and reduce the air flow
	Wright R-2600-8 front-row cylinder	
41S-42S-43S	9	To make reference tests of standard baffles for comparison with tests of special baffles
46-48-49	10	To test best combination of special baffles, as determined in front-row single-cylinder and multicylinder tests

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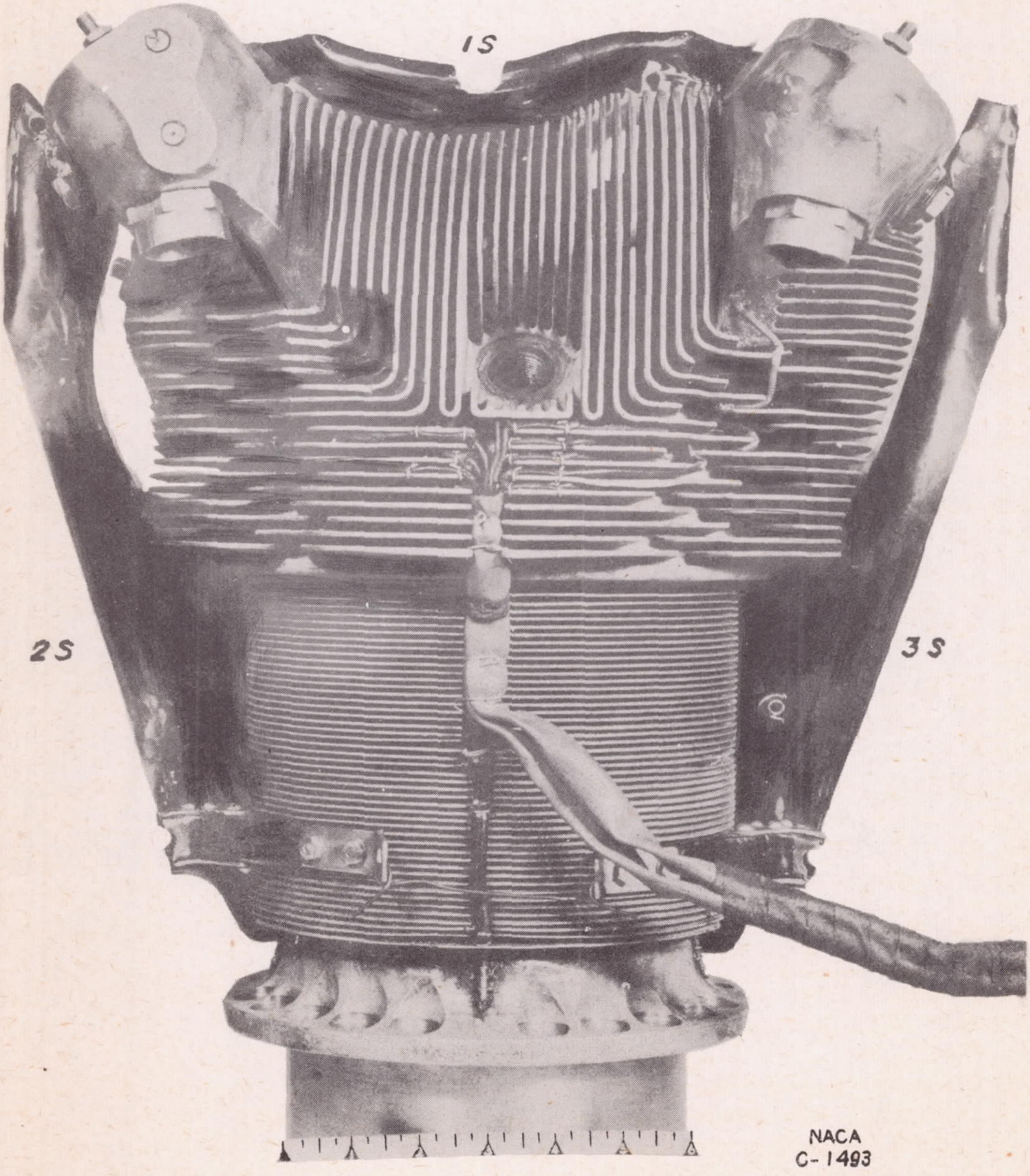
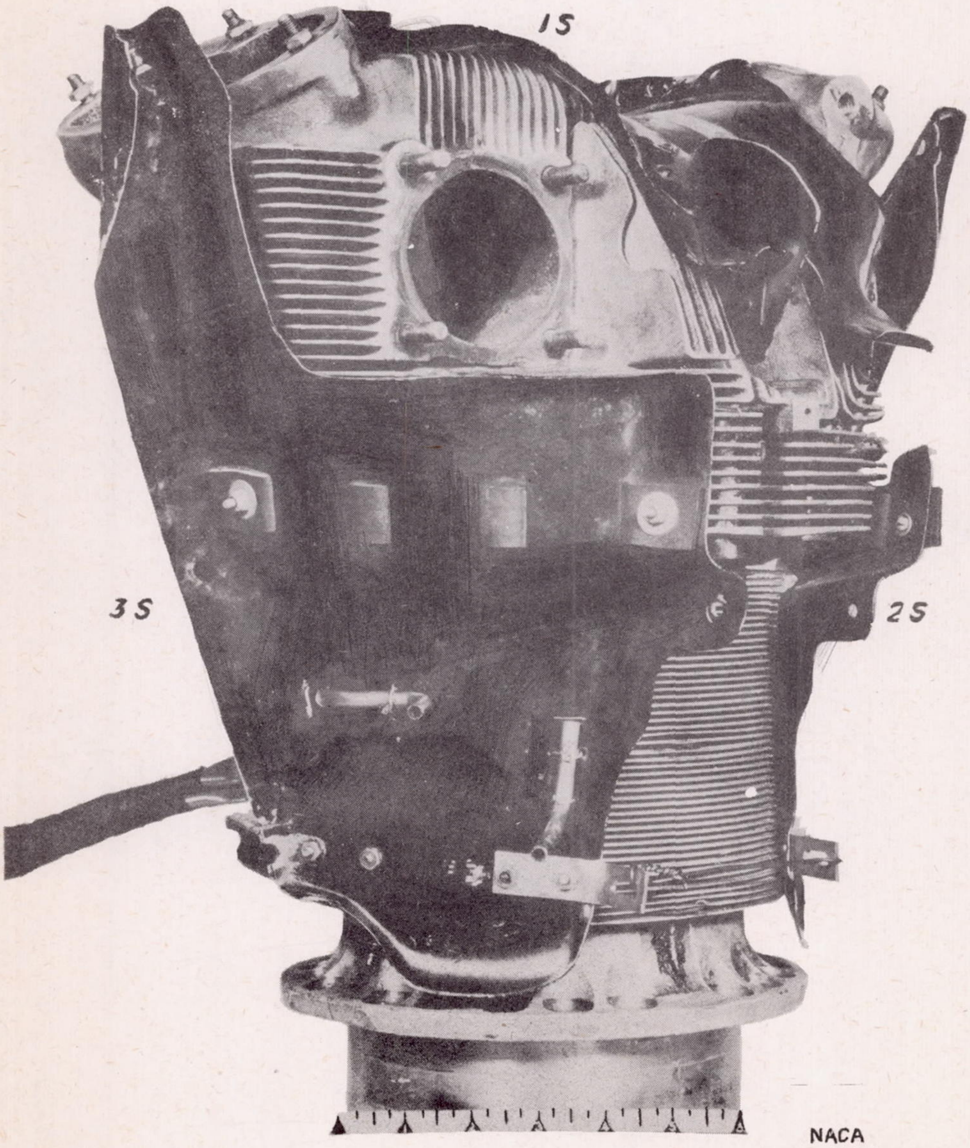


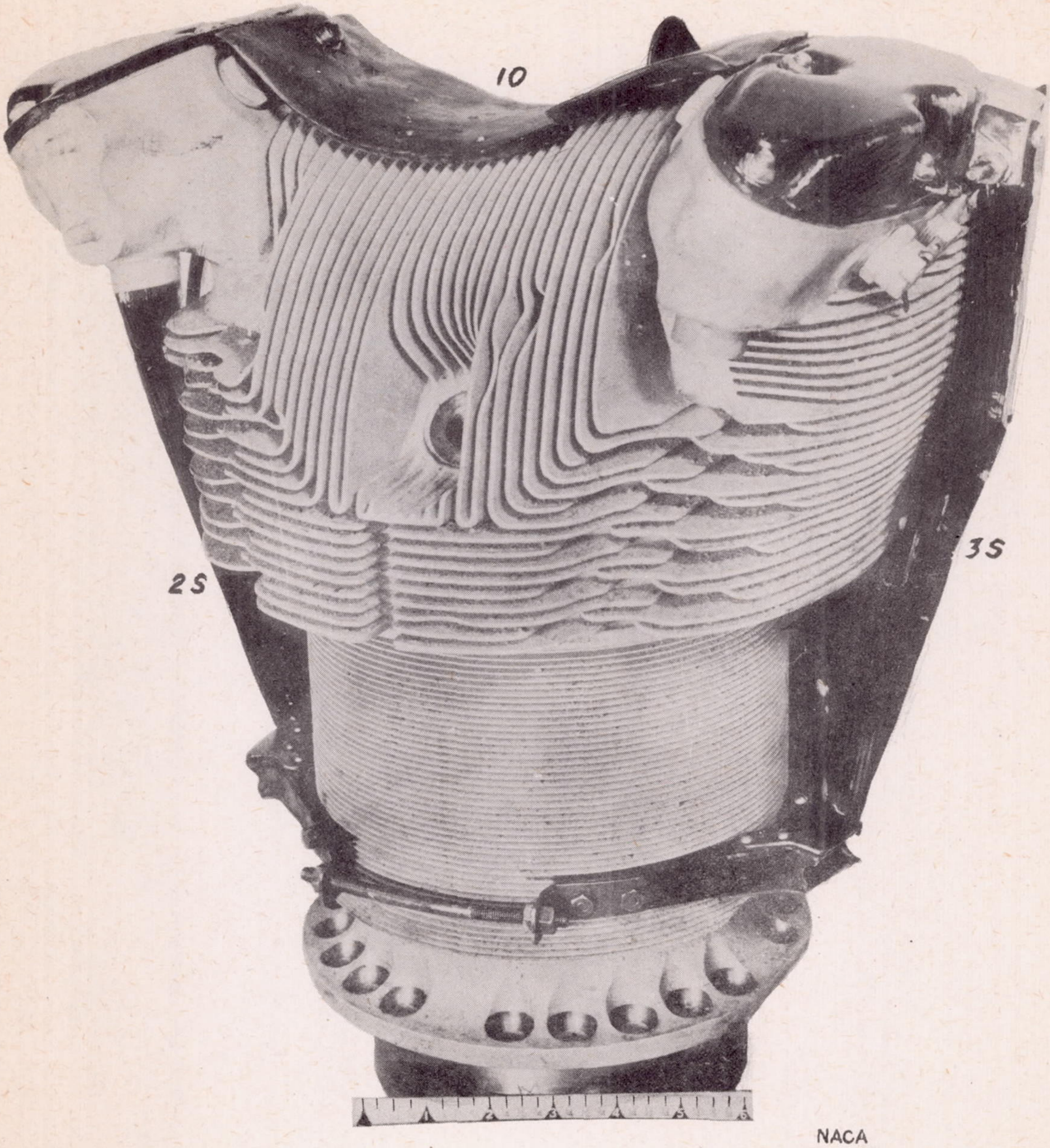
(a) Front view.

Figure 1. - 1820 G200 cylinder, standard baffles 1S-2S-3S.



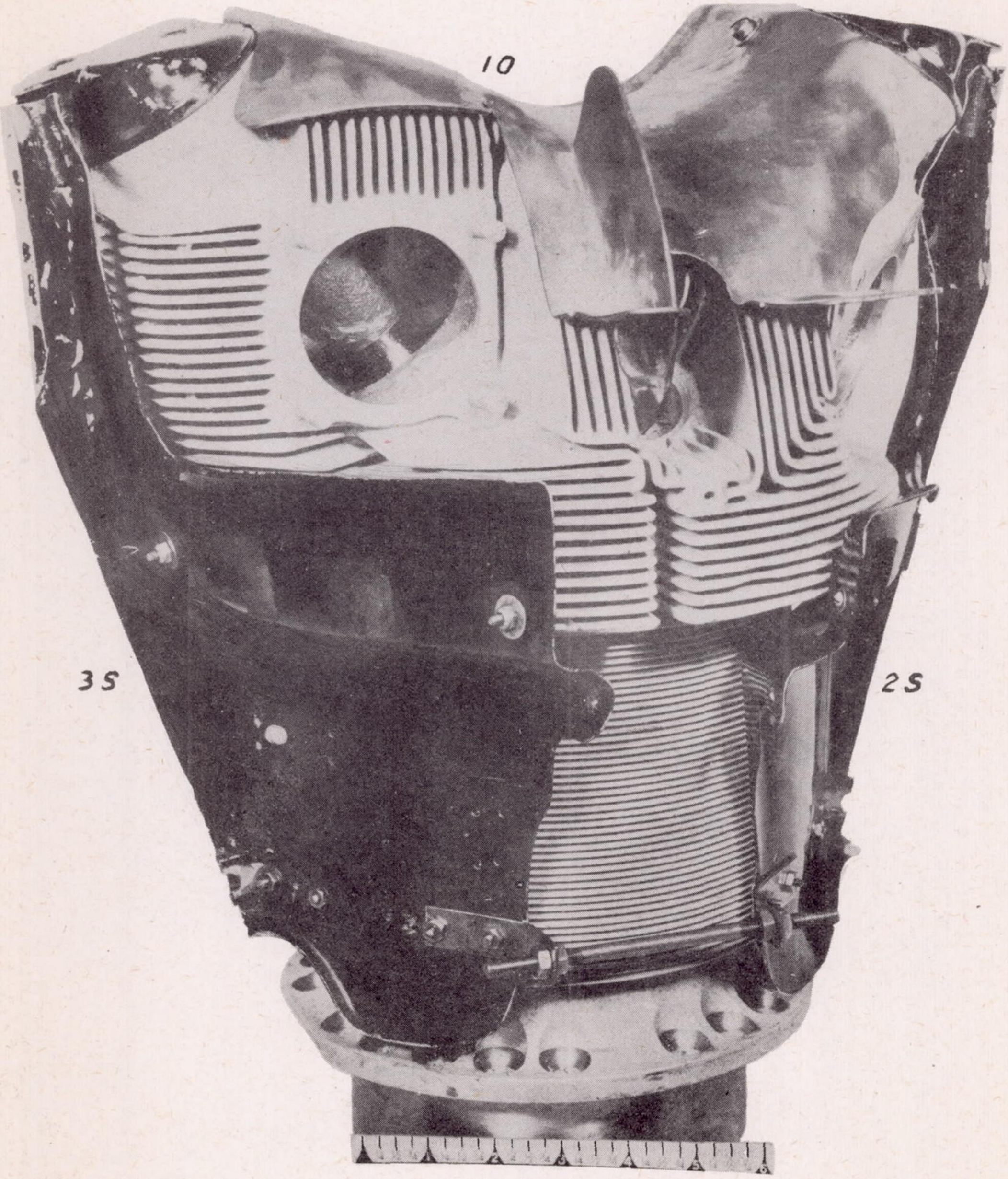
(b) Rear view.

Figure 1. - Concluded. 1820 G200 cylinder, standard baffles 1S-2S-3S.



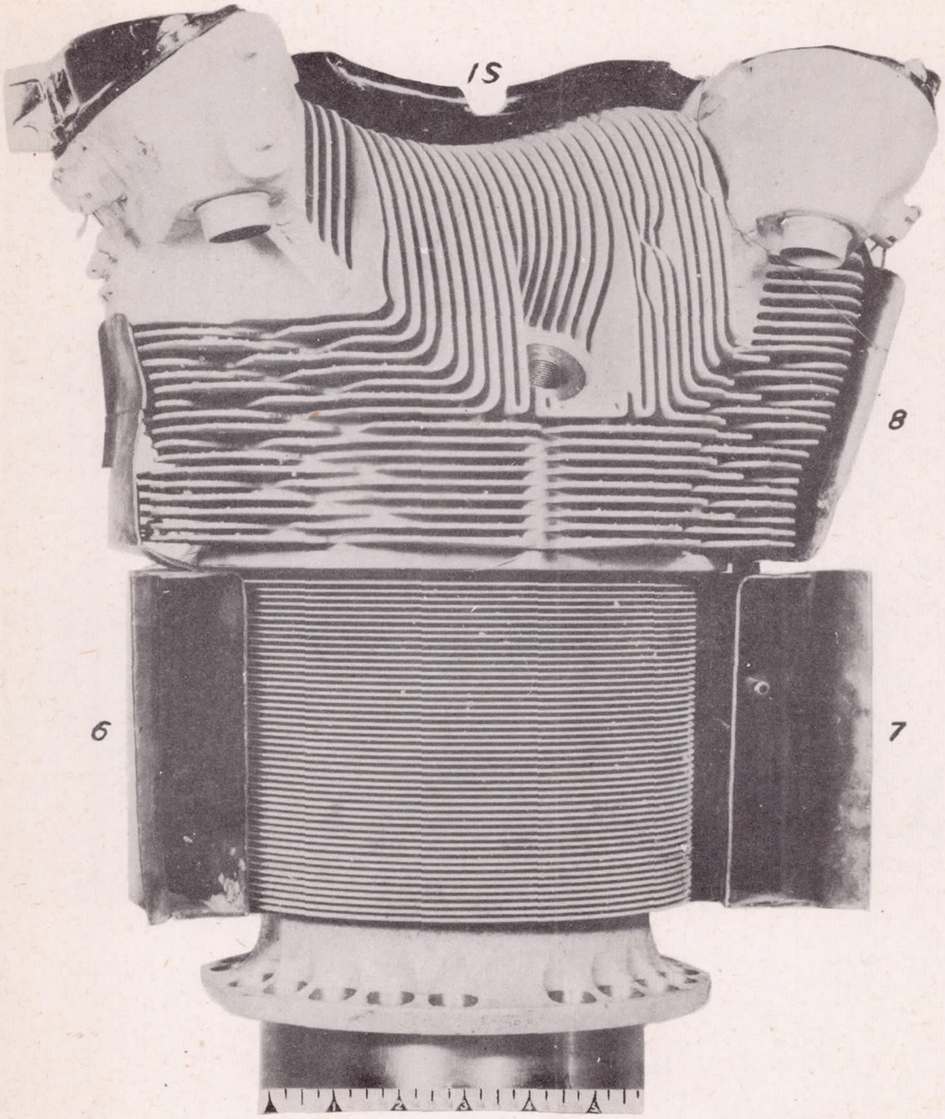
(a) Front view.

Figure 2. - 1820 G200 cylinder, baffles 10-2S-3S.



(b) Rear view.

Figure 2. - Concluded. 1820 G200 cylinder, baffles 10-2S-3S.



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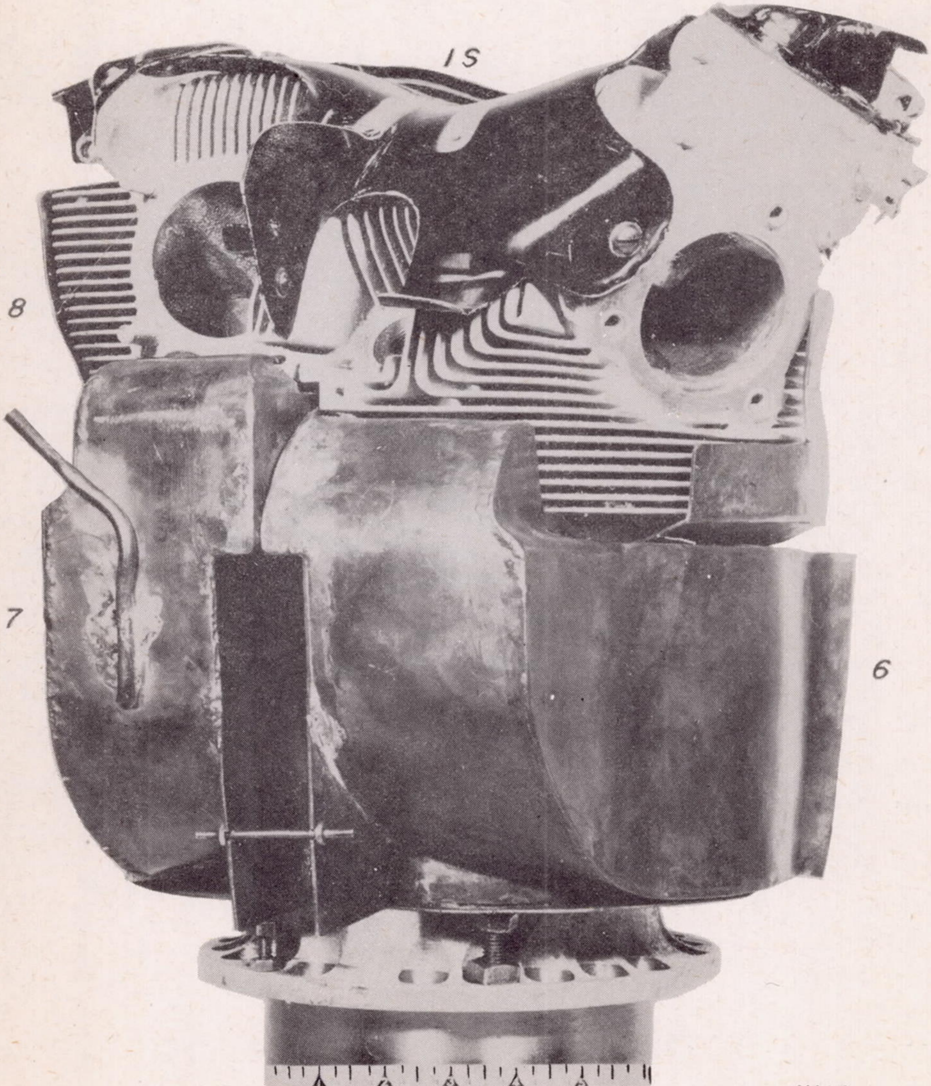
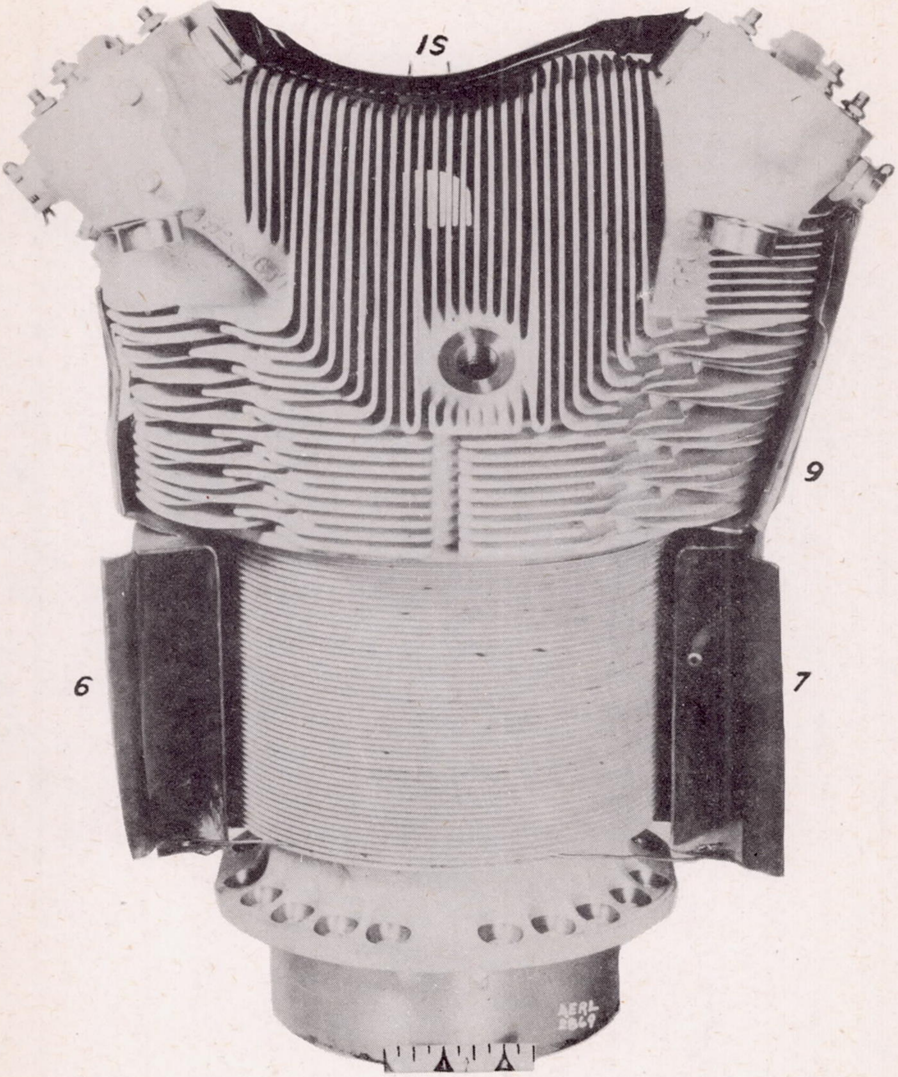
(a) Front view.

Figure 3. - 1820 G200 cylinder, baffles 1S-6-7-8.



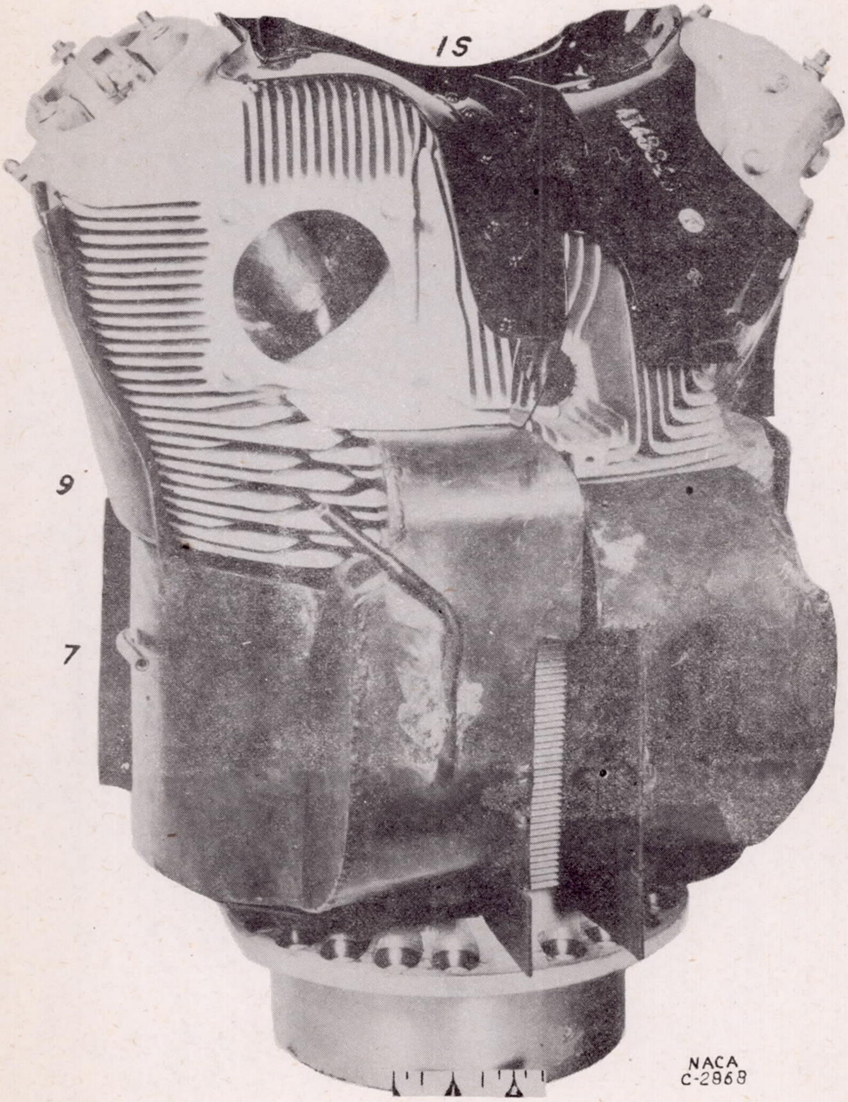
(b) Rear view.

Figure 3. - Concluded. 1820 G200 cylinder, baffles 1S-6-7-8.



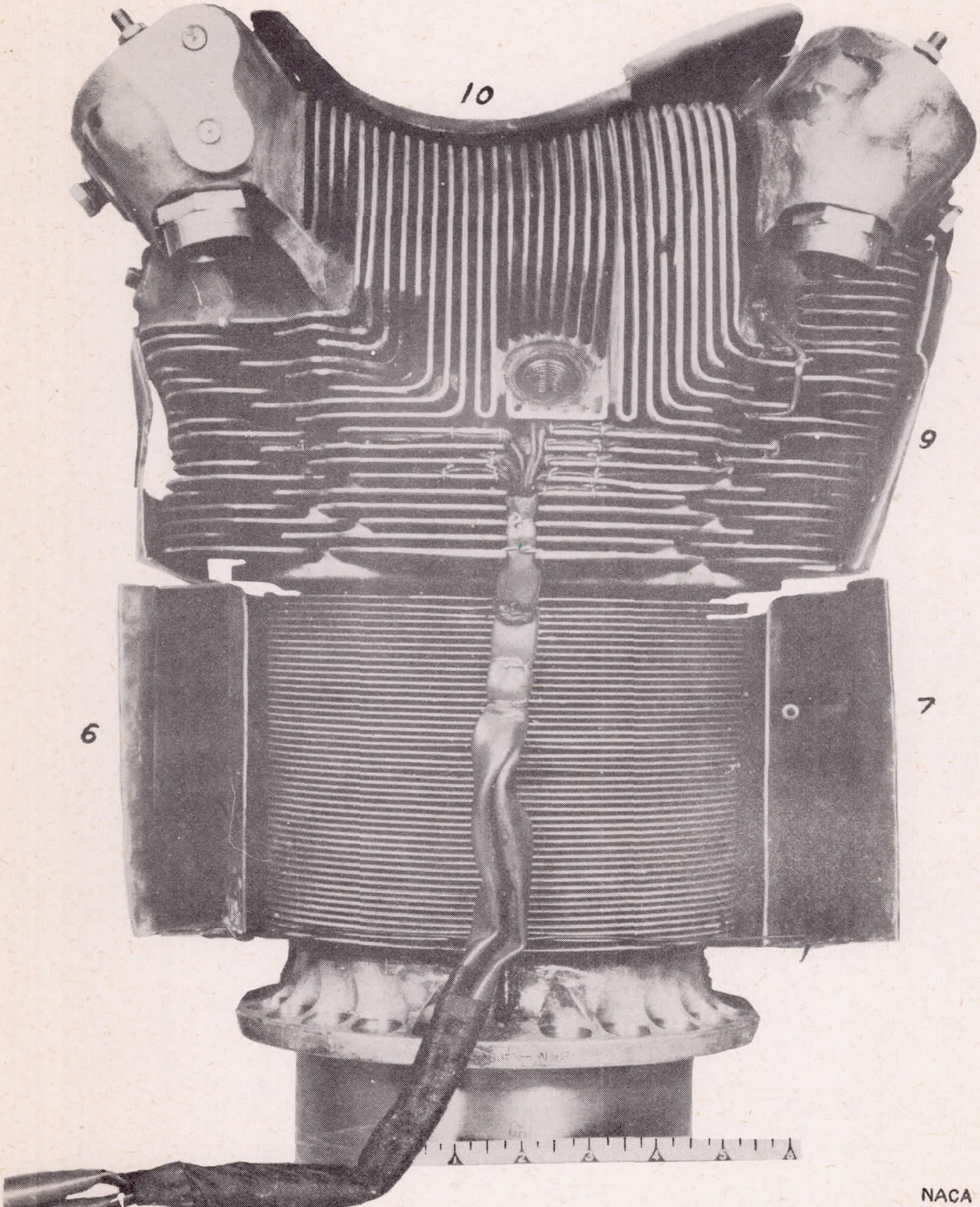
(a) Front view.

Figure 4. - 1820 G200 cylinder, baffles 1S-6-7-9.



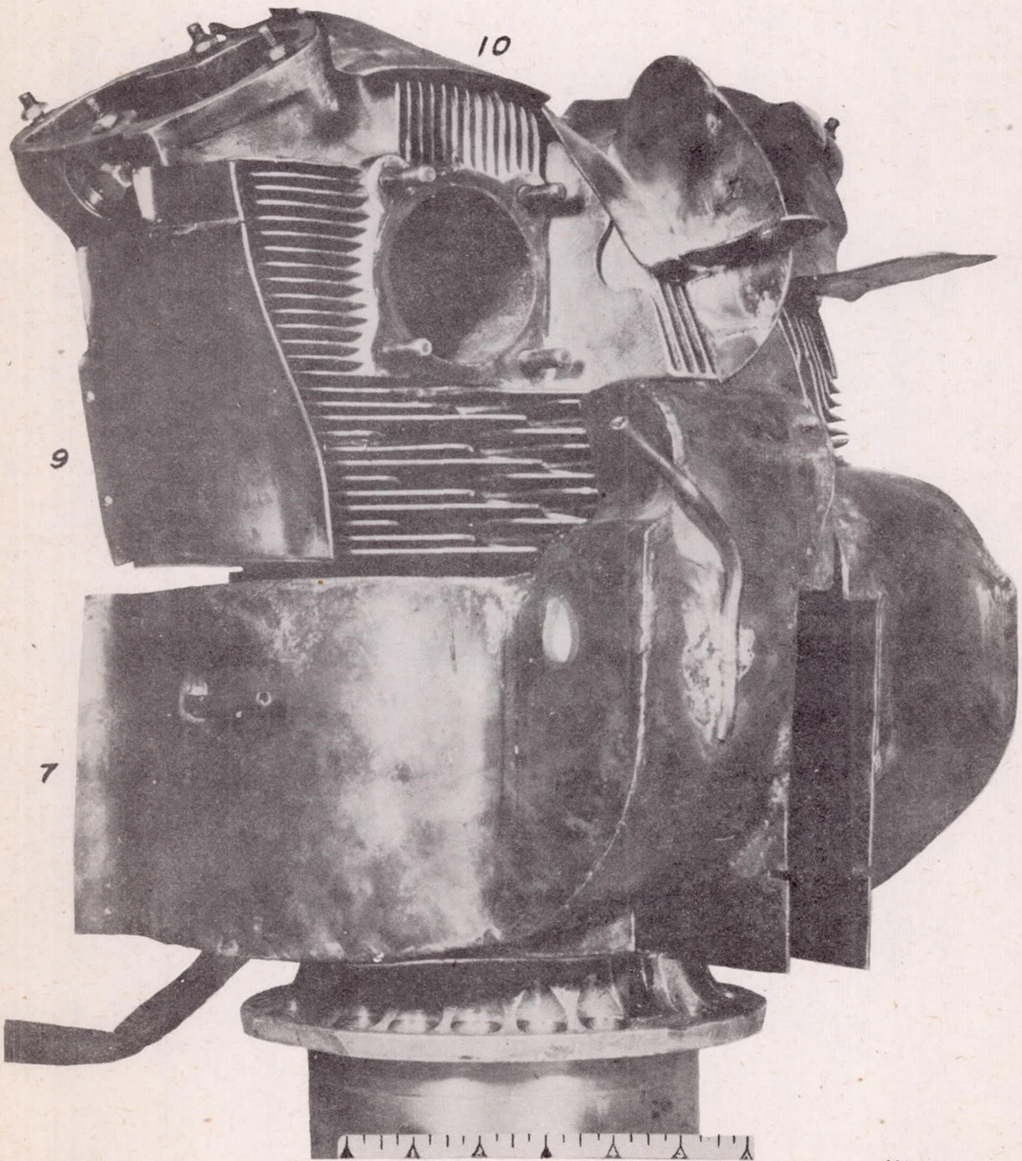
(b) Rear view.

Figure 4. - Concluded. 1820 G200 cylinder, baffles 1S-6-7-9.



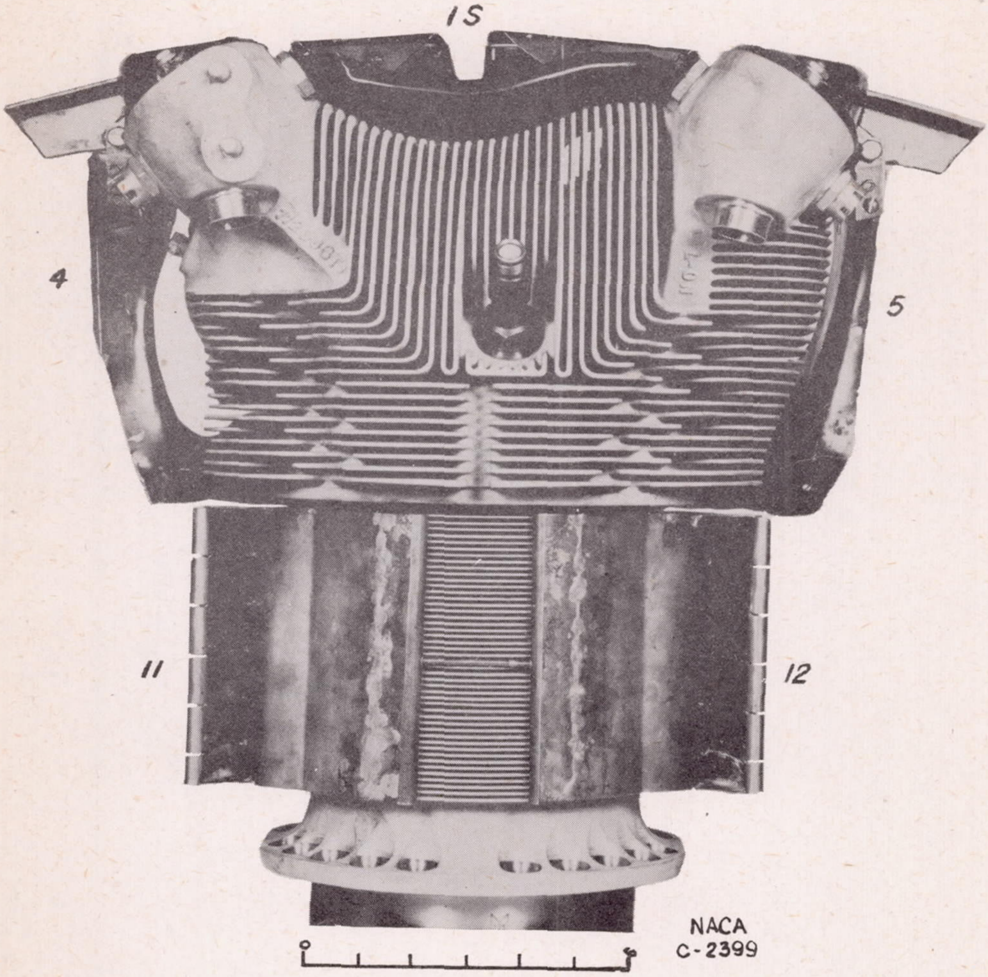
(a) Front view.

Figure 5. - 1820 G200 cylinder, baffles 10-6-7-9.



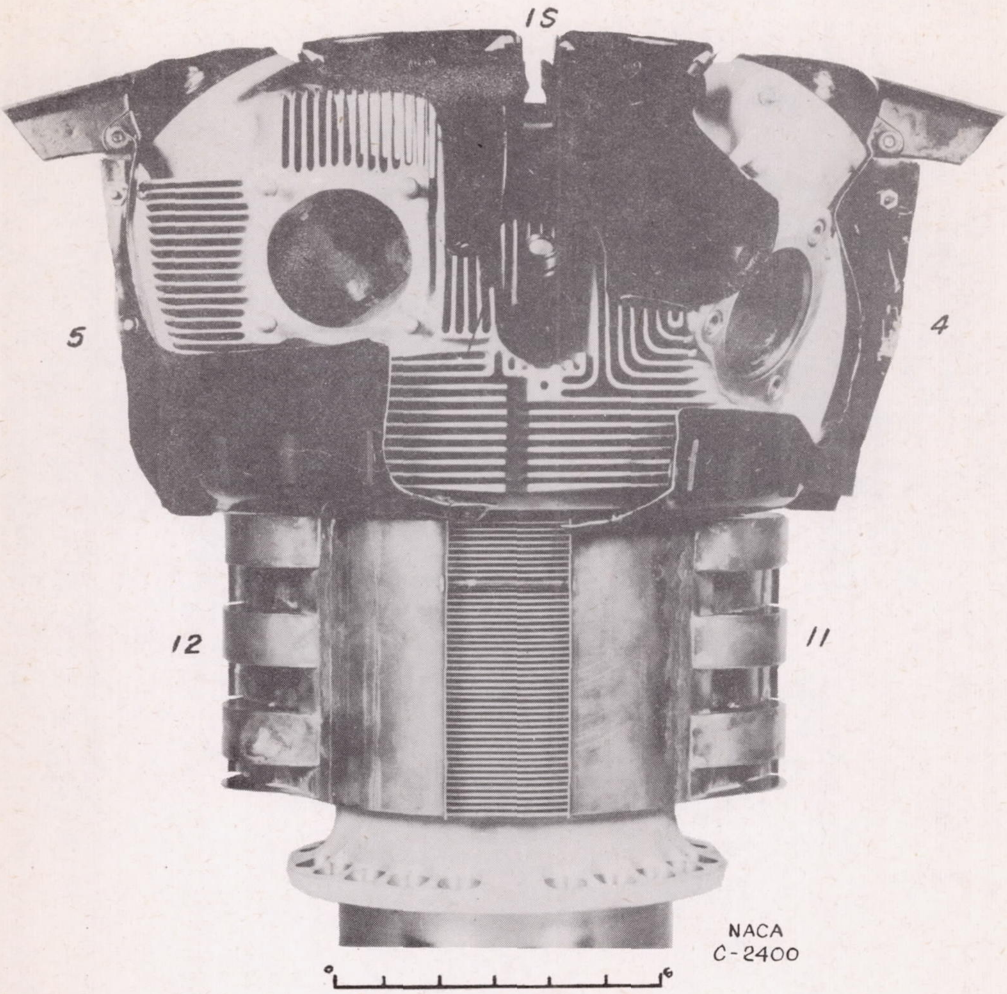
(b) Rear view.

Figure 5. - Concluded. 1820 G200 cylinder, baffles 10-6-7-9.



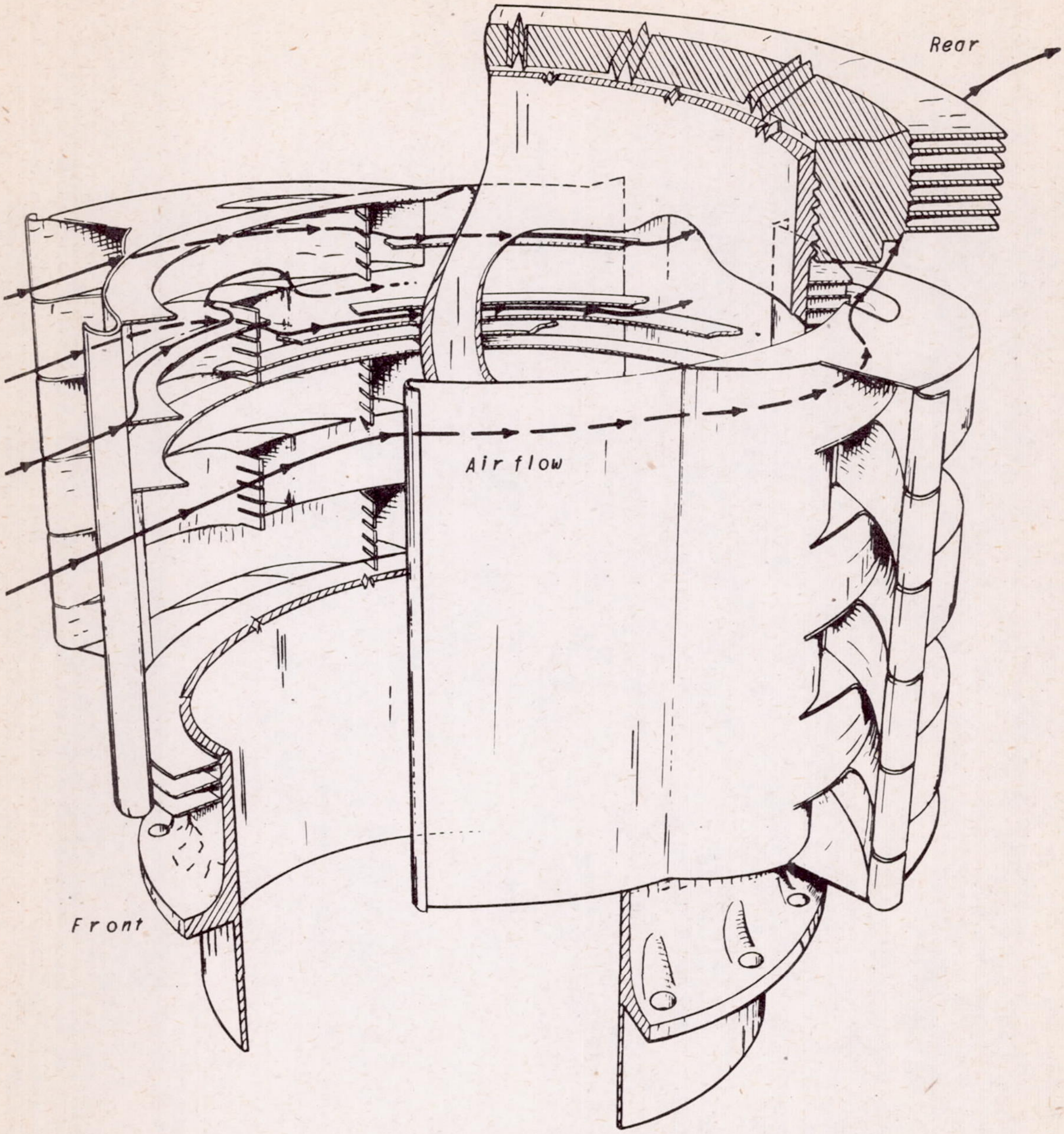
(a) Front view.

Figure 6. - 1820 G200 cylinder, baffles 1S-4-5-11-12.



(b) Rear view.

Figure 6. - Continued. 1820 G200 cylinder, baffles 1S-4-5-11-12.



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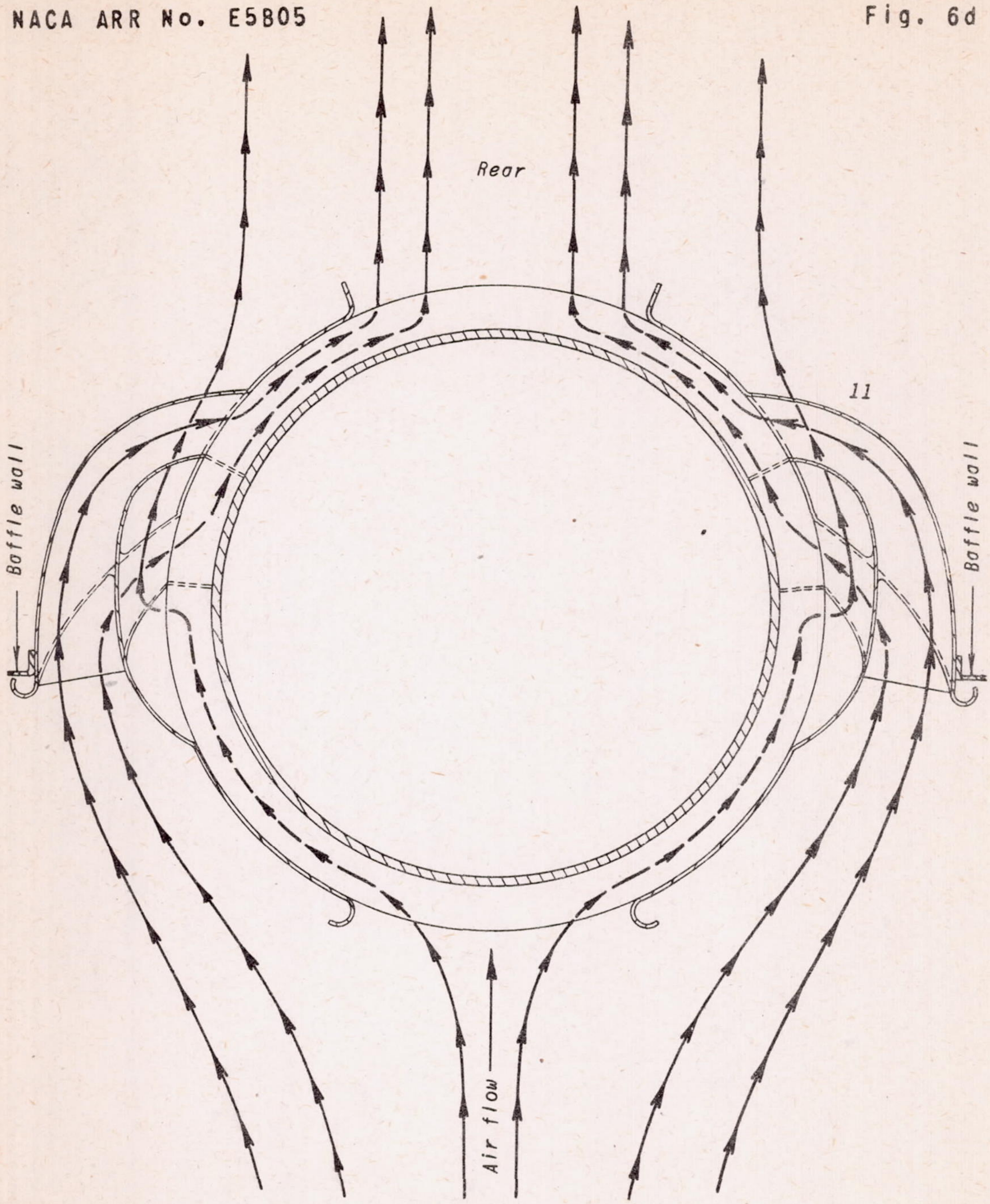
(c) Barrel cooling-air flow paths, front view.

Figure 6. - Continued. 1820 G200 cylinder, baffles 1S-4-5-11-12



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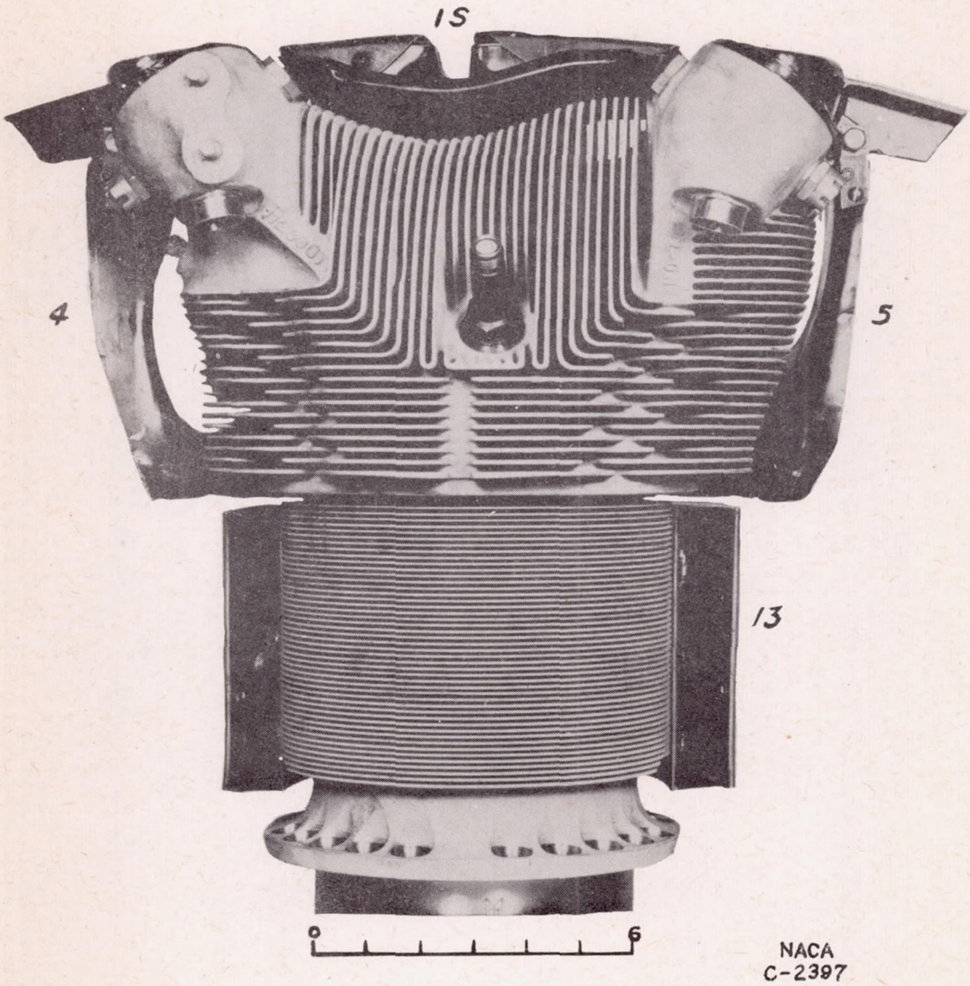
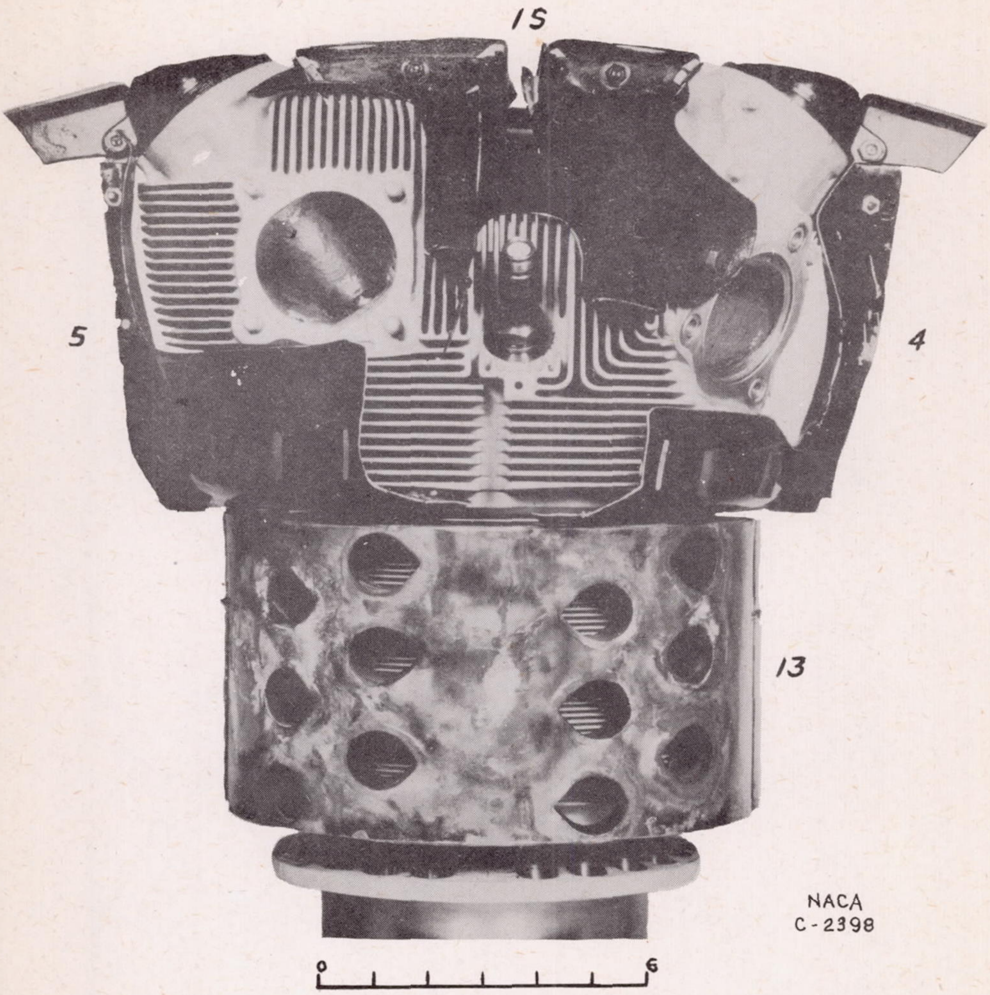
(d) Barrel cooling-air flow paths, top view.

Figure 6. - Concluded. 1820 G200 cylinder, baffles 1S-4-5-11-12.



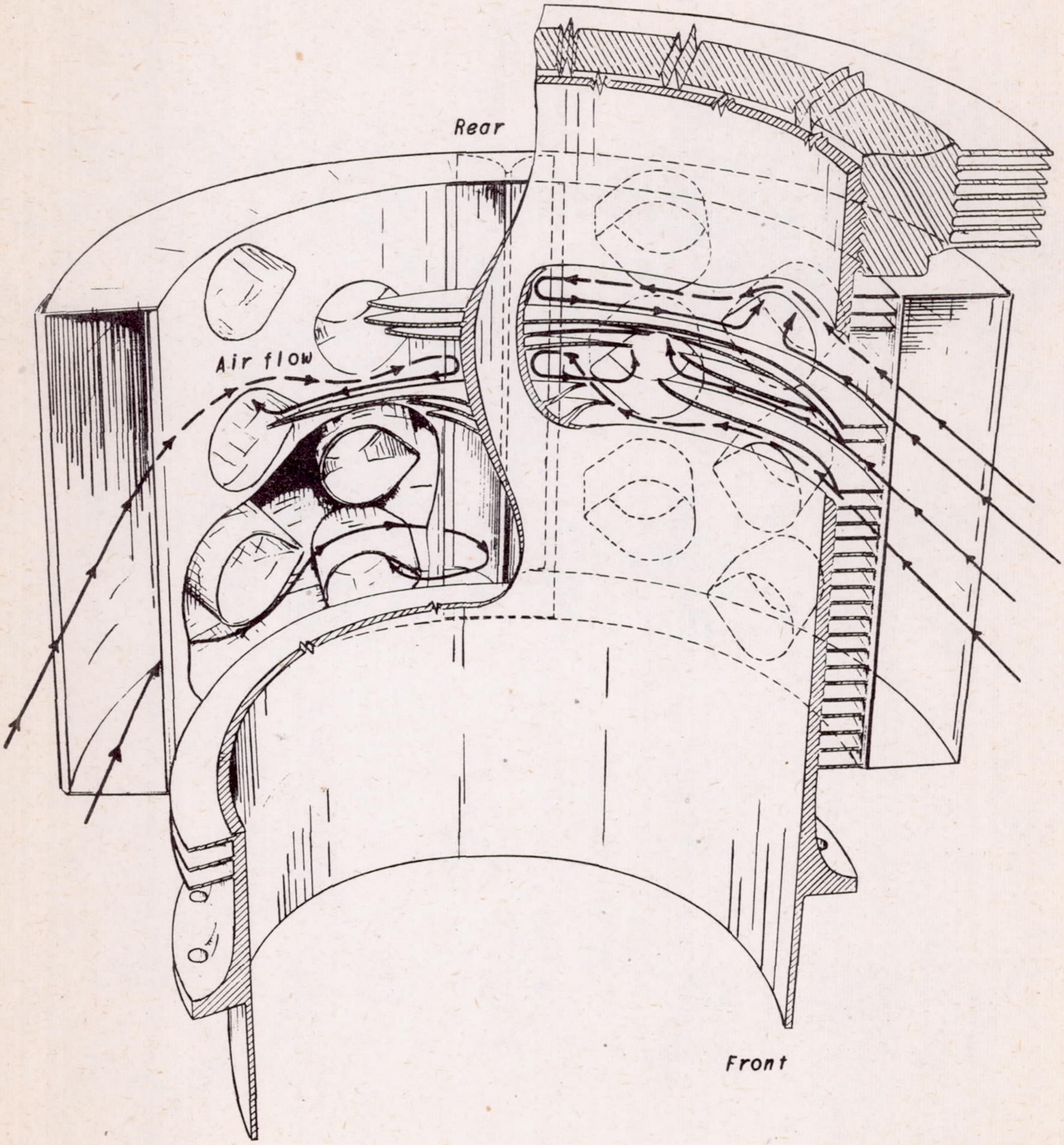
(a) Front view.

Figure 7. - 1820 G200 cylinder, baffles 1S-4-5-13.



(b) Rear view.

Figure 7. - Continued. 1820 G200 cylinder, baffles 1S-4-5-13.



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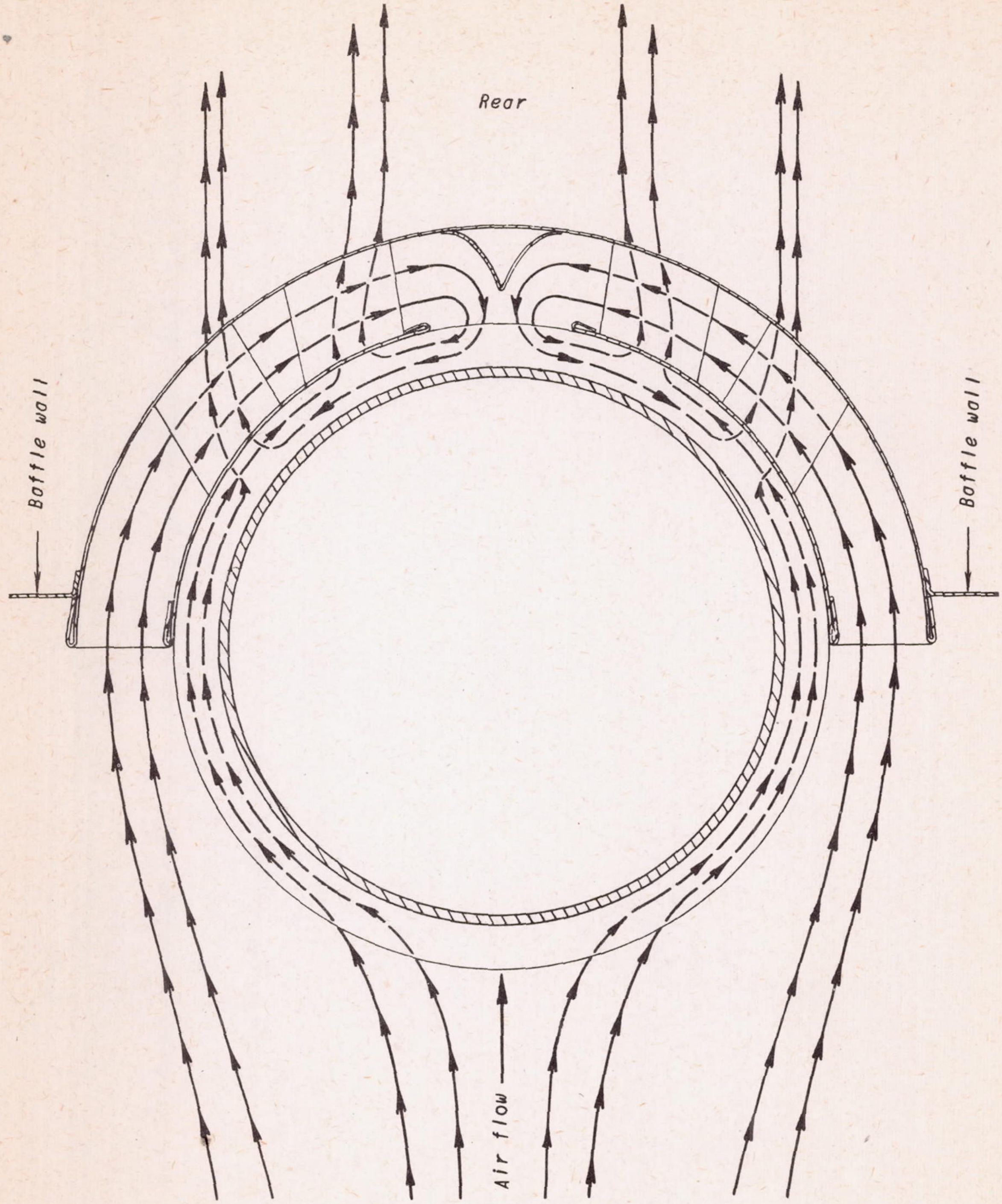
(c) Barrel cooling-air flow paths, front view.

Figure 7. - Continued. 1820 G200 cylinder, baffles 1S-4-5-13.



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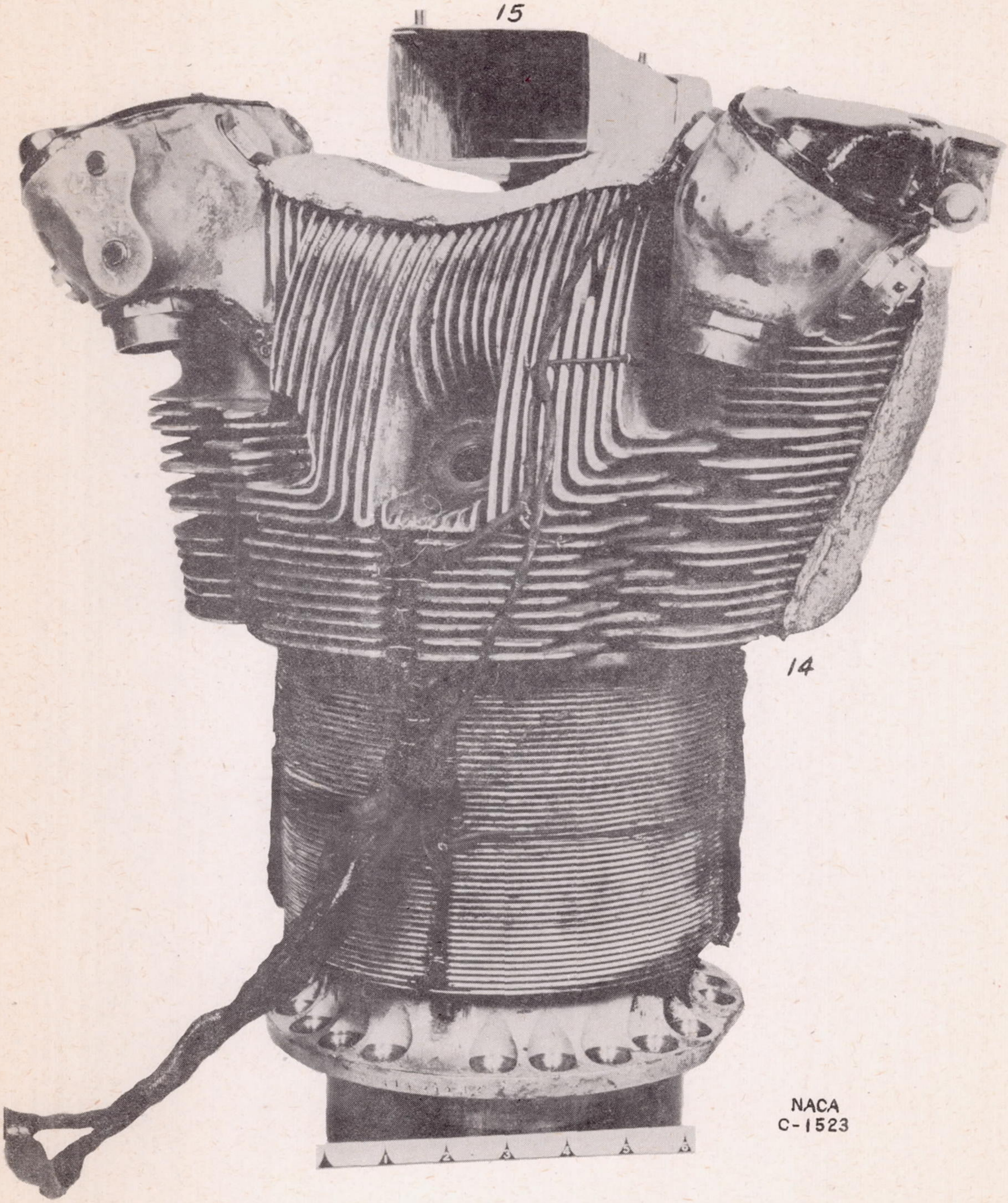
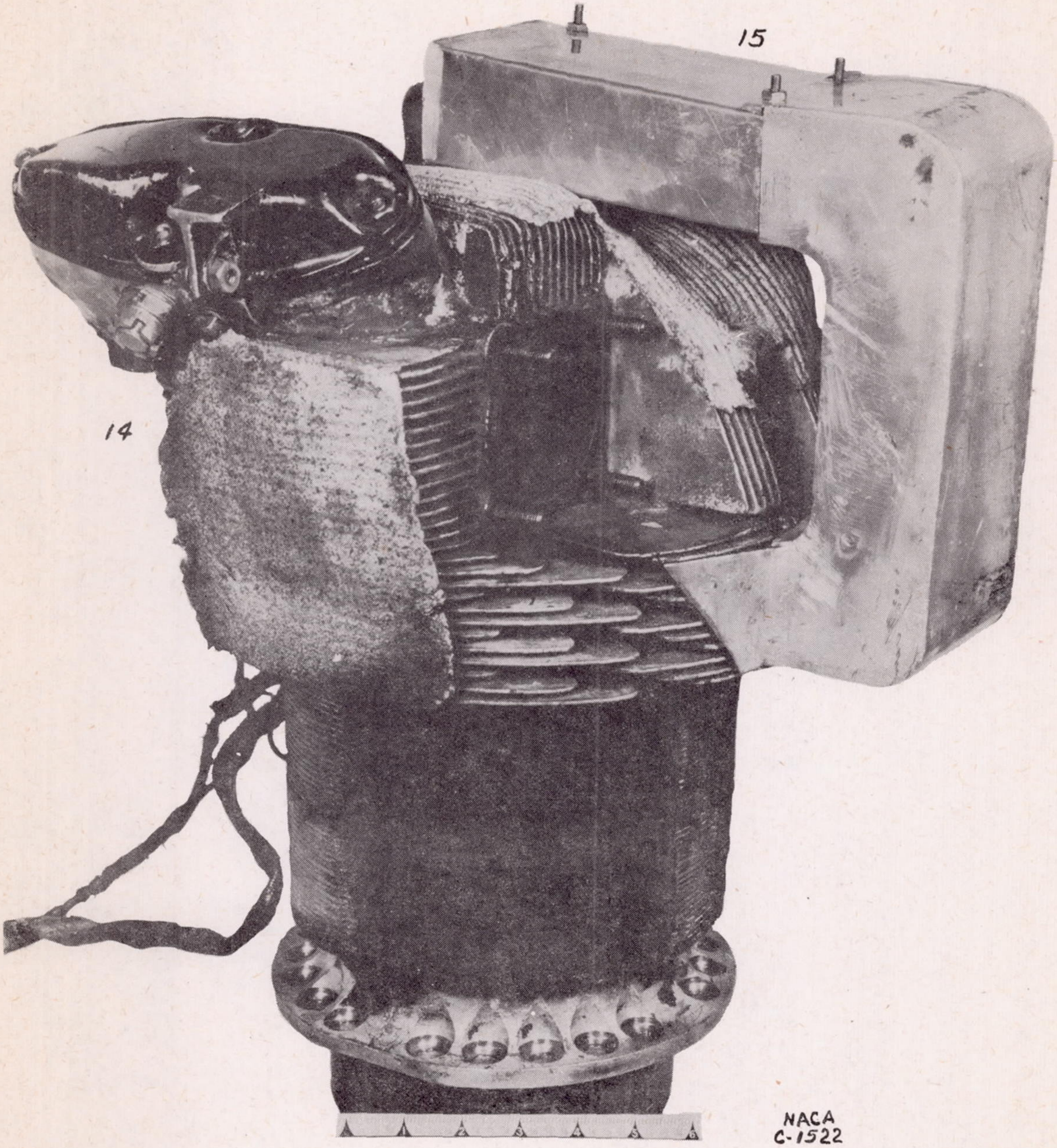
(d) Barrel cooling-air flow paths, top view.

Figure 7. - Concluded. 1820 G200 cylinder, baffles 1S-4-5-13.



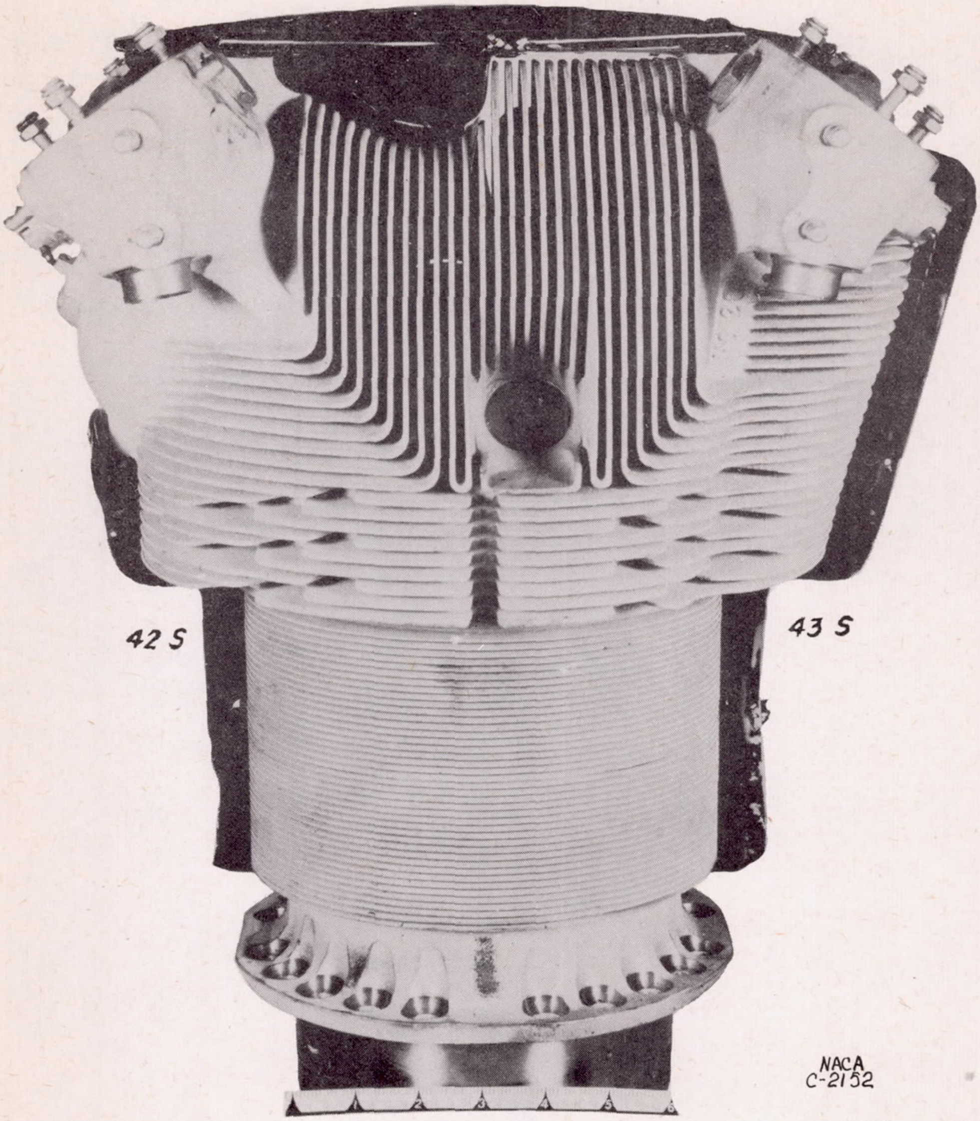
(a) Front view.

Figure 8. - 1820 G200 cylinder, baffles 14-15.



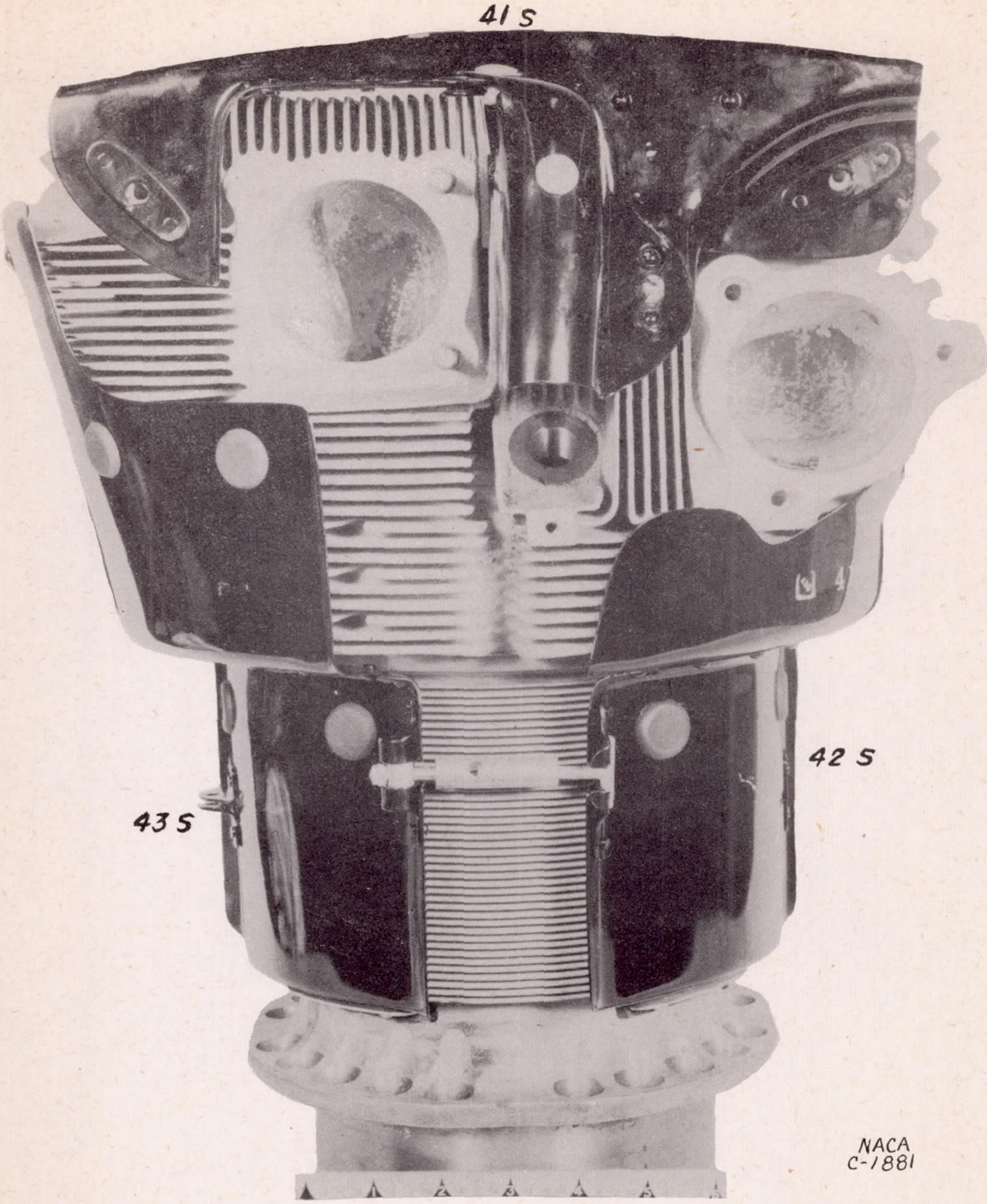
(b) Rear view.

Figure 8. - Concluded. 1820 G200 cylinder, baffles 14-15.



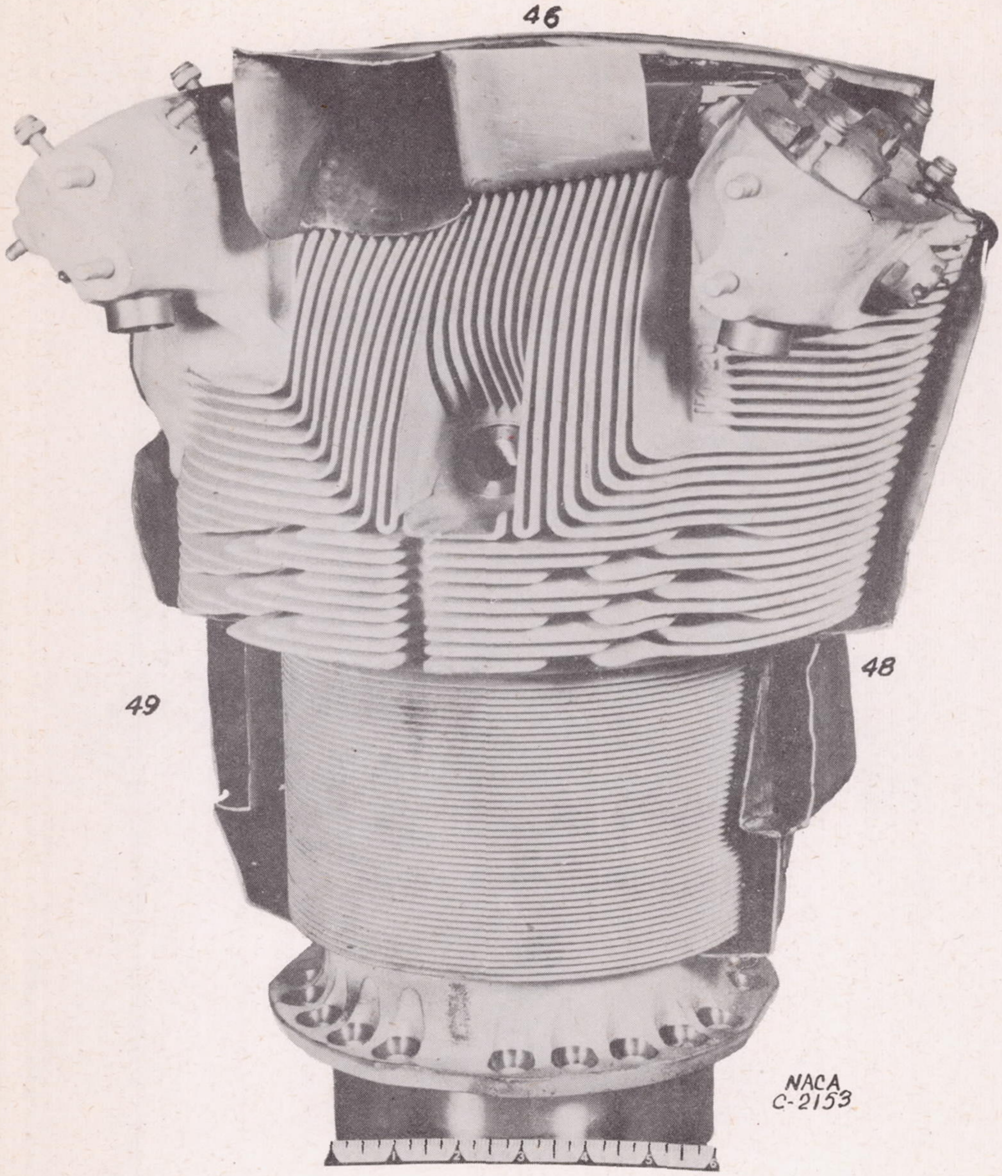
(a) Front view.

Figure 9. - 2600-8 cylinder, front row, baffles 41S-42S-43S.



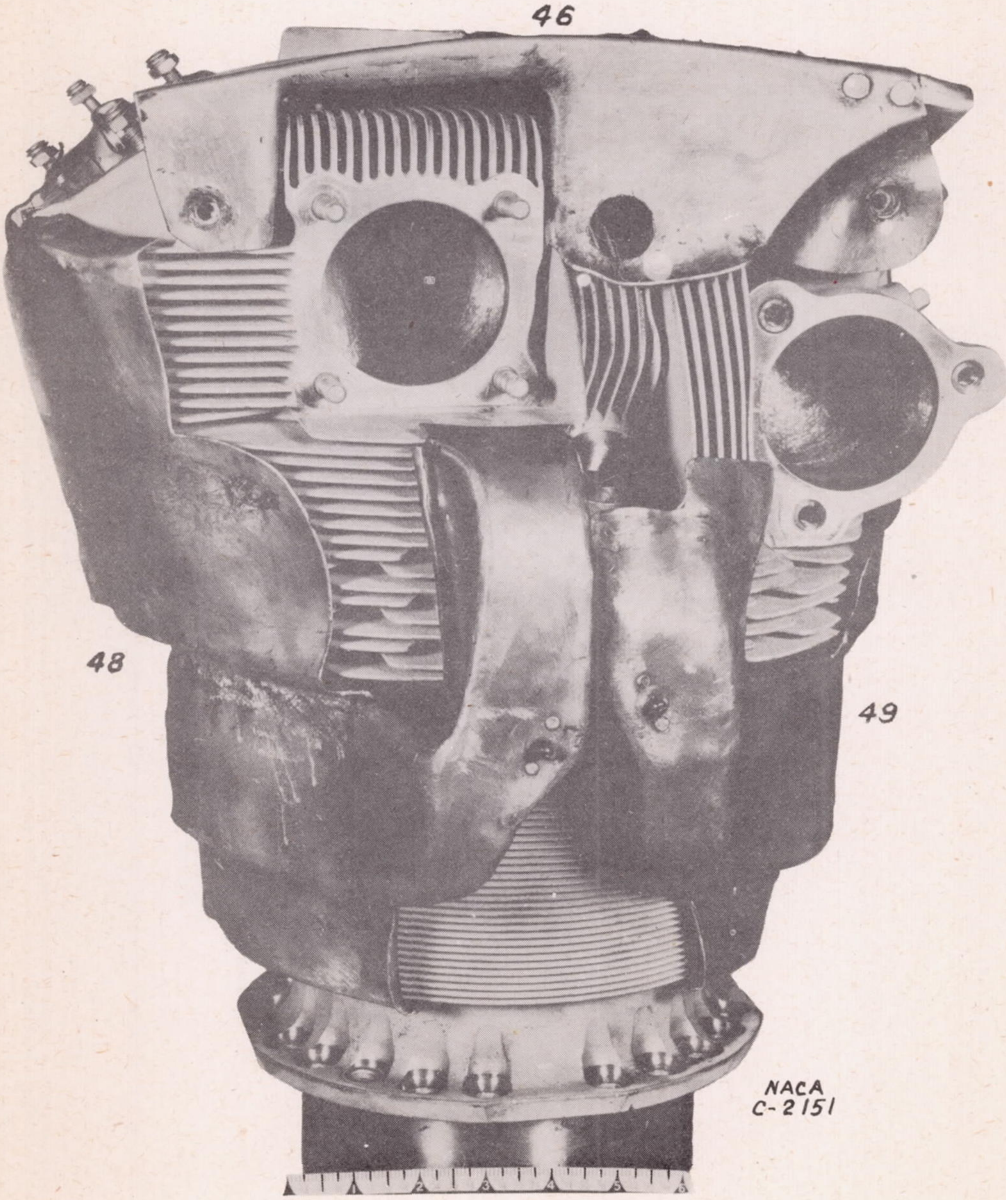
(b) Rear view.

Figure 9. - Concluded. 2600-8 cylinder, front row, baffles 41S-42S-43S-



(a) Front view.

Figure 10. - 2600-8 cylinder, front row, baffles 46-48-49.



(b) Rear view.

Figure 10. - Concluded. 2600-8 cylinder, front row, baffles 46-48-49.

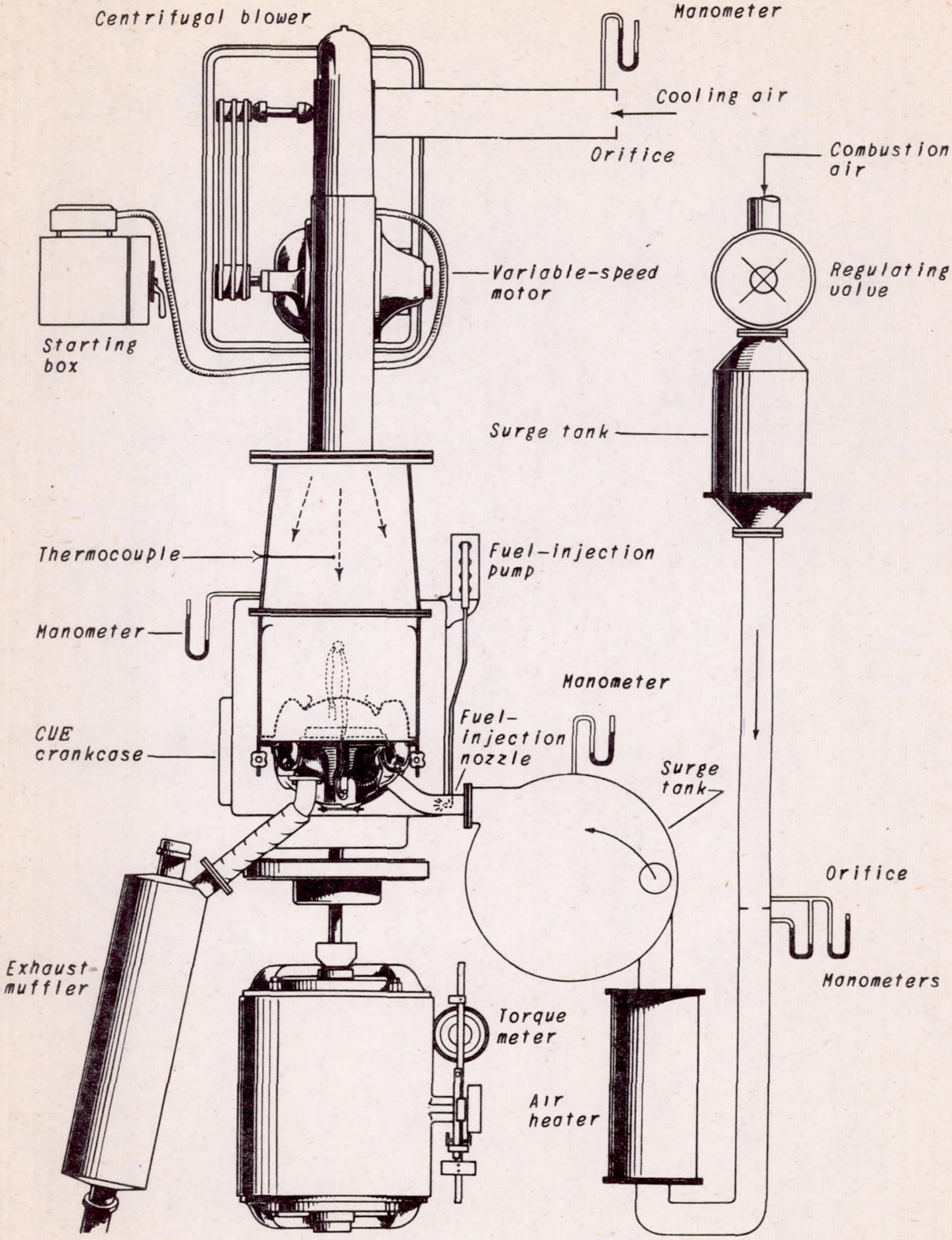


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Figure 11. - 1820 G200 single-cylinder-test engine setup.

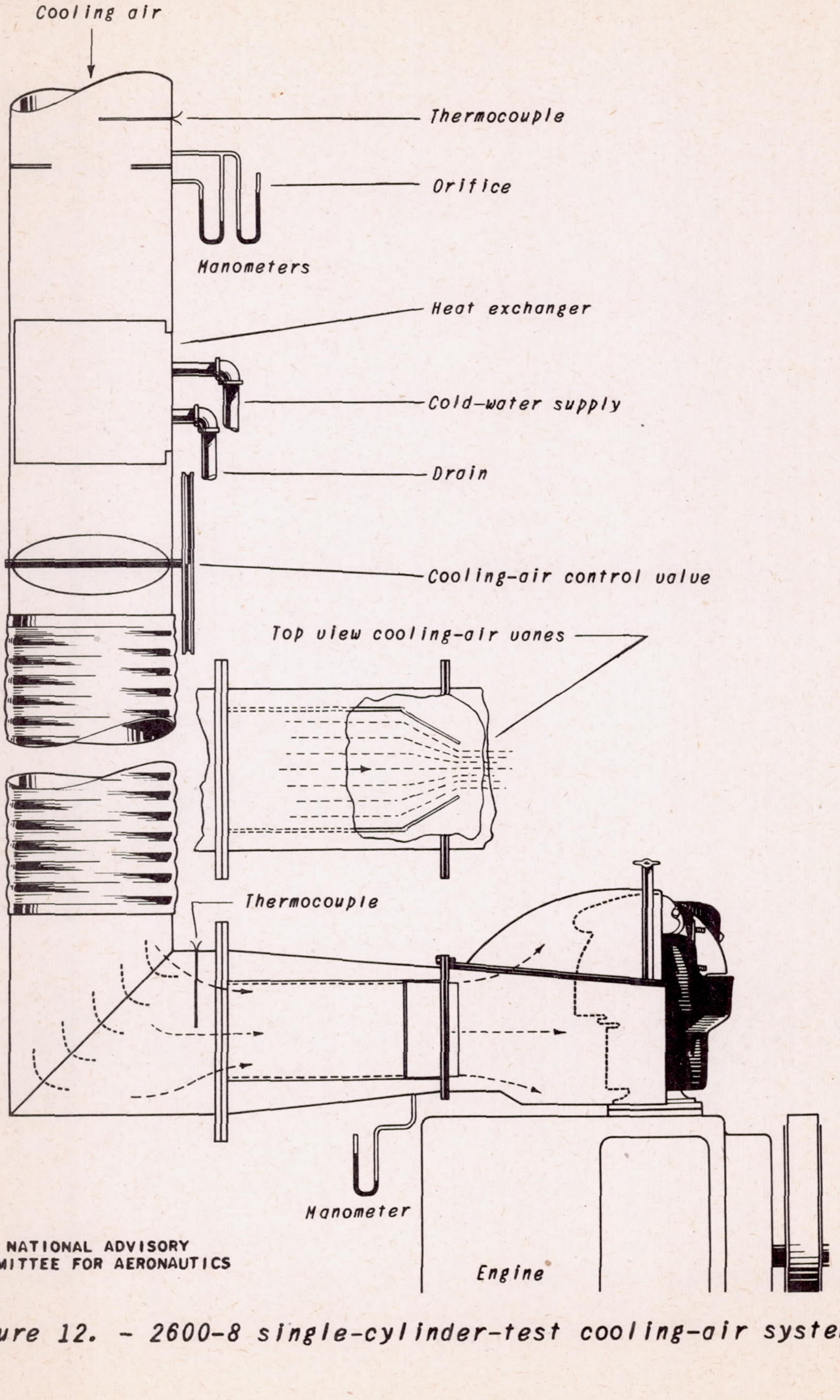

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Figure 12. - 2600-8 single-cylinder-test cooling-air system.

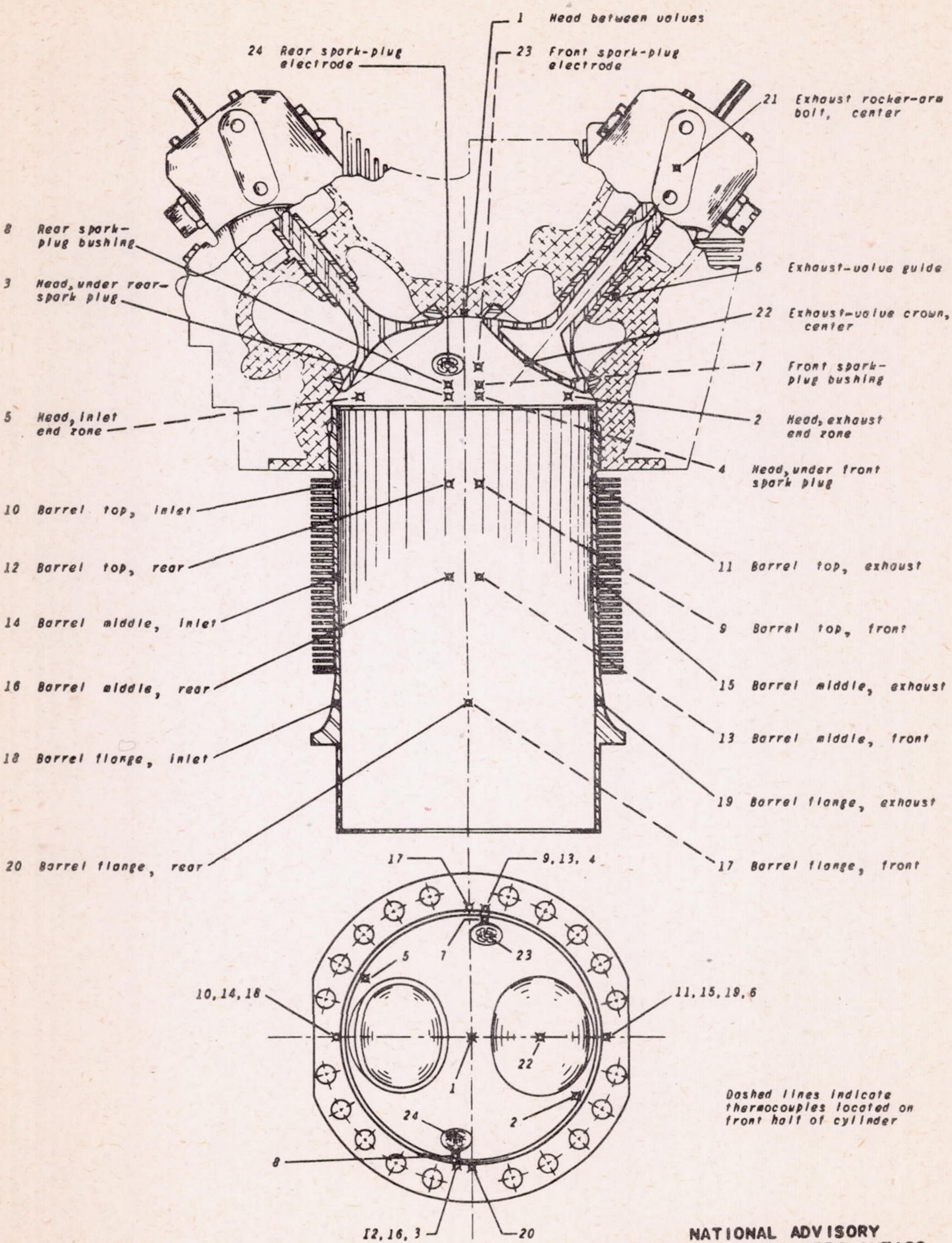

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Figure 13.- Location of the thermocouples on cylinders.

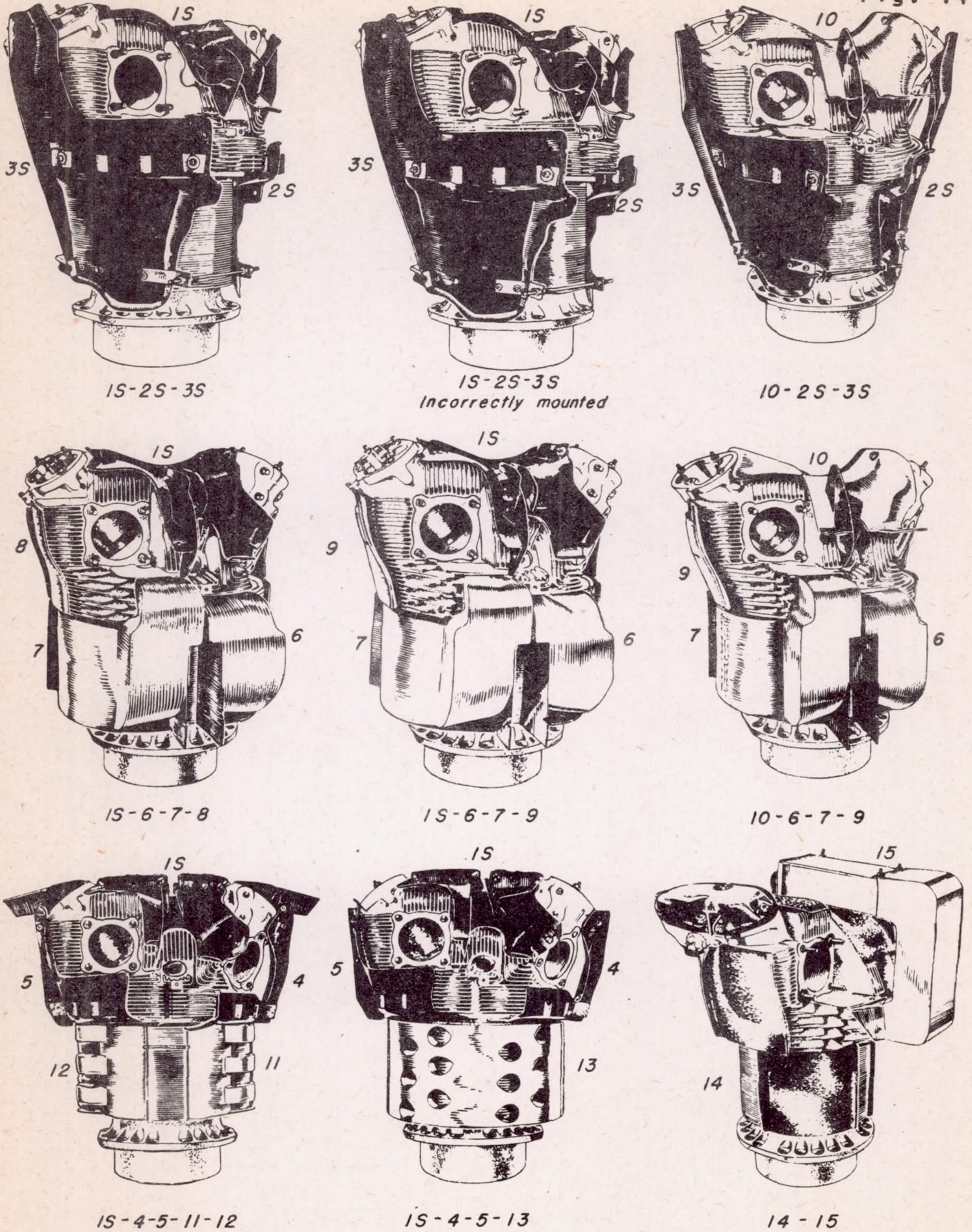

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Figure 14. - Baffle combinations tested on a Wright 1820 G200 cylinder in single-cylinder tests.

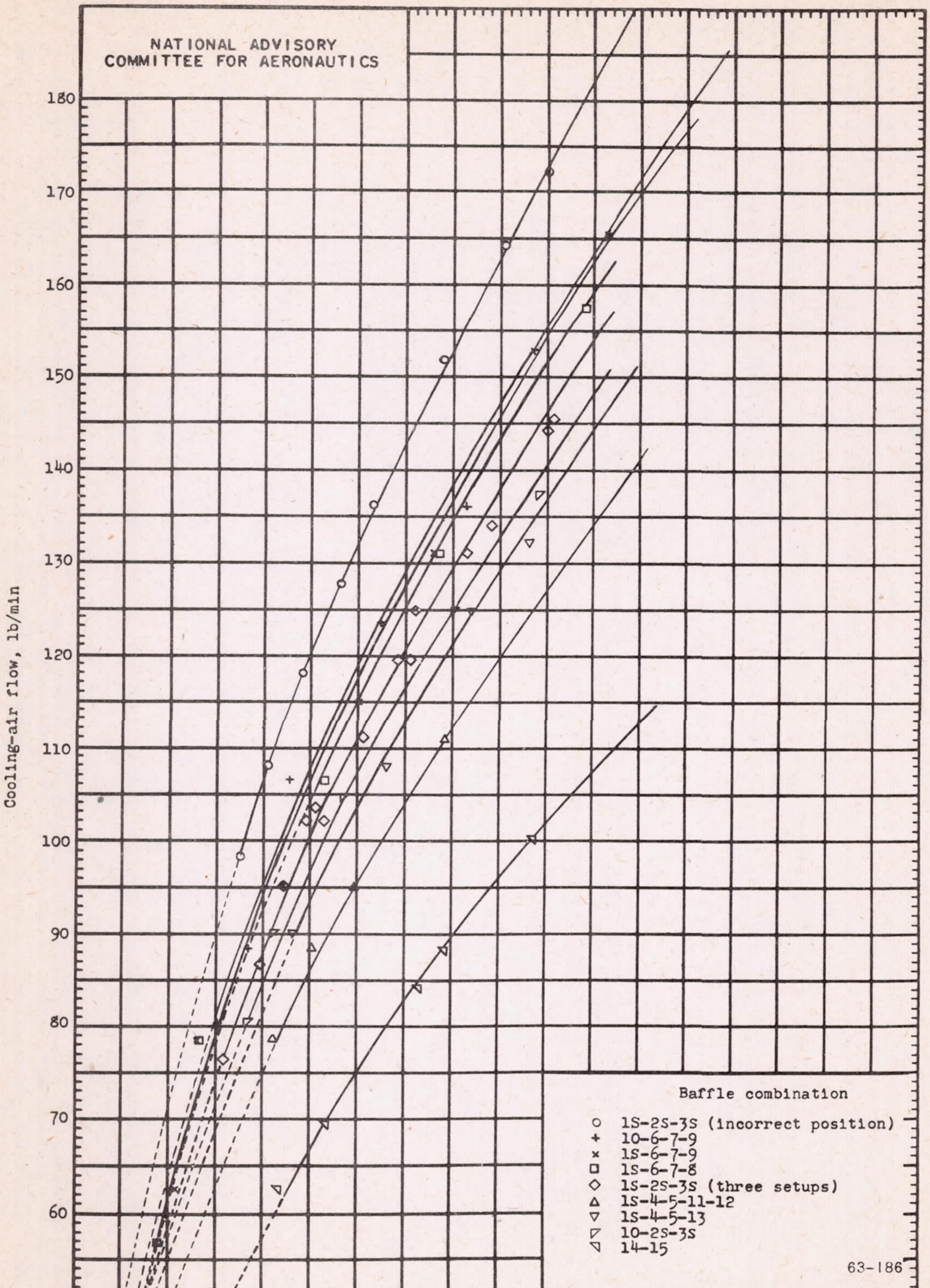


Figure 15. - Cooling-air flow for the baffles on a Wright 1820 G200 cylinder in single-cylinder tests. Indicated horsepower, 66; engine speed, 2000 rpm; manifold pressure, 31 inches of mercury absolute; fuel-air ratio, 0.083; cooling-air temperature, 100° F.

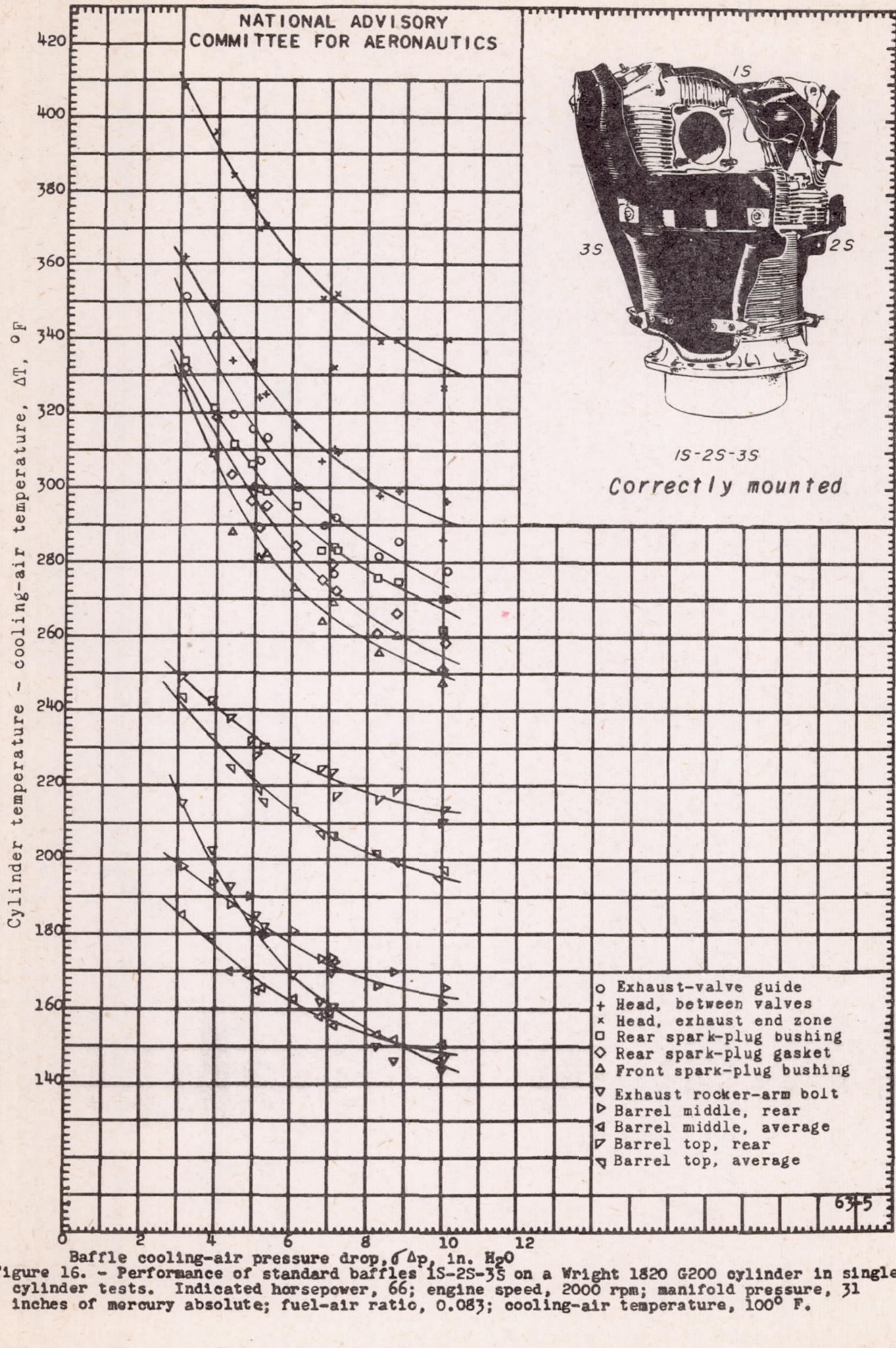


Figure 16. - Performance of standard baffles 1S-2S-3S on a Wright 1820 G200 cylinder in single-cylinder tests. Indicated horsepower, 66; engine speed, 2000 rpm; manifold pressure, 31 inches of mercury absolute; fuel-air ratio, 0.083; cooling-air temperature, 100° F.

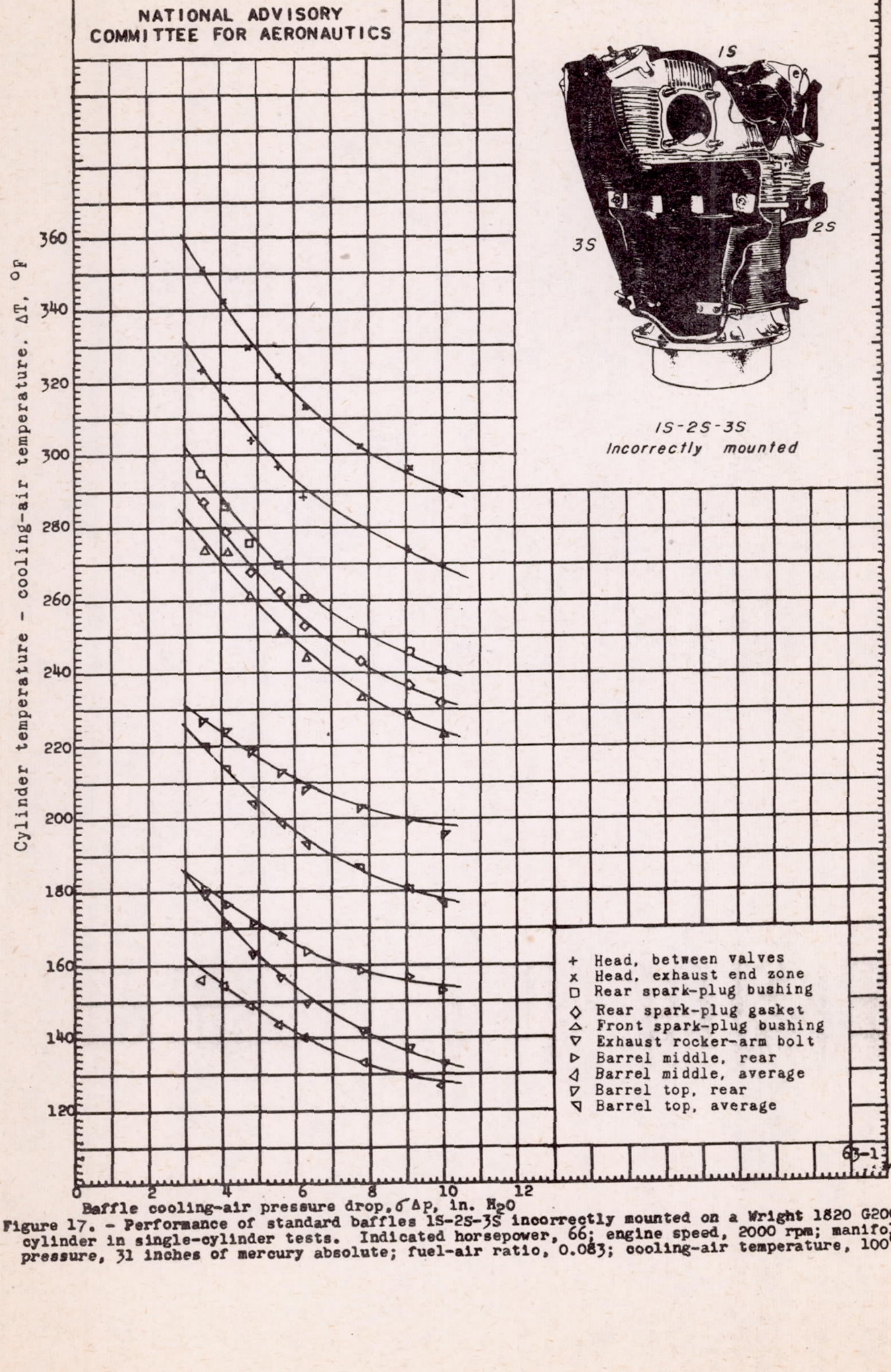


Figure 17. - Performance of standard baffles 1S-2S-3S incorrectly mounted on a Wright 1820 G200 cylinder in single-cylinder tests. Indicated horsepower, 66; engine speed, 2000 rpm; manifold pressure, 31 inches of mercury absolute; fuel-air ratio, 0.083; cooling-air temperature, 100° F.

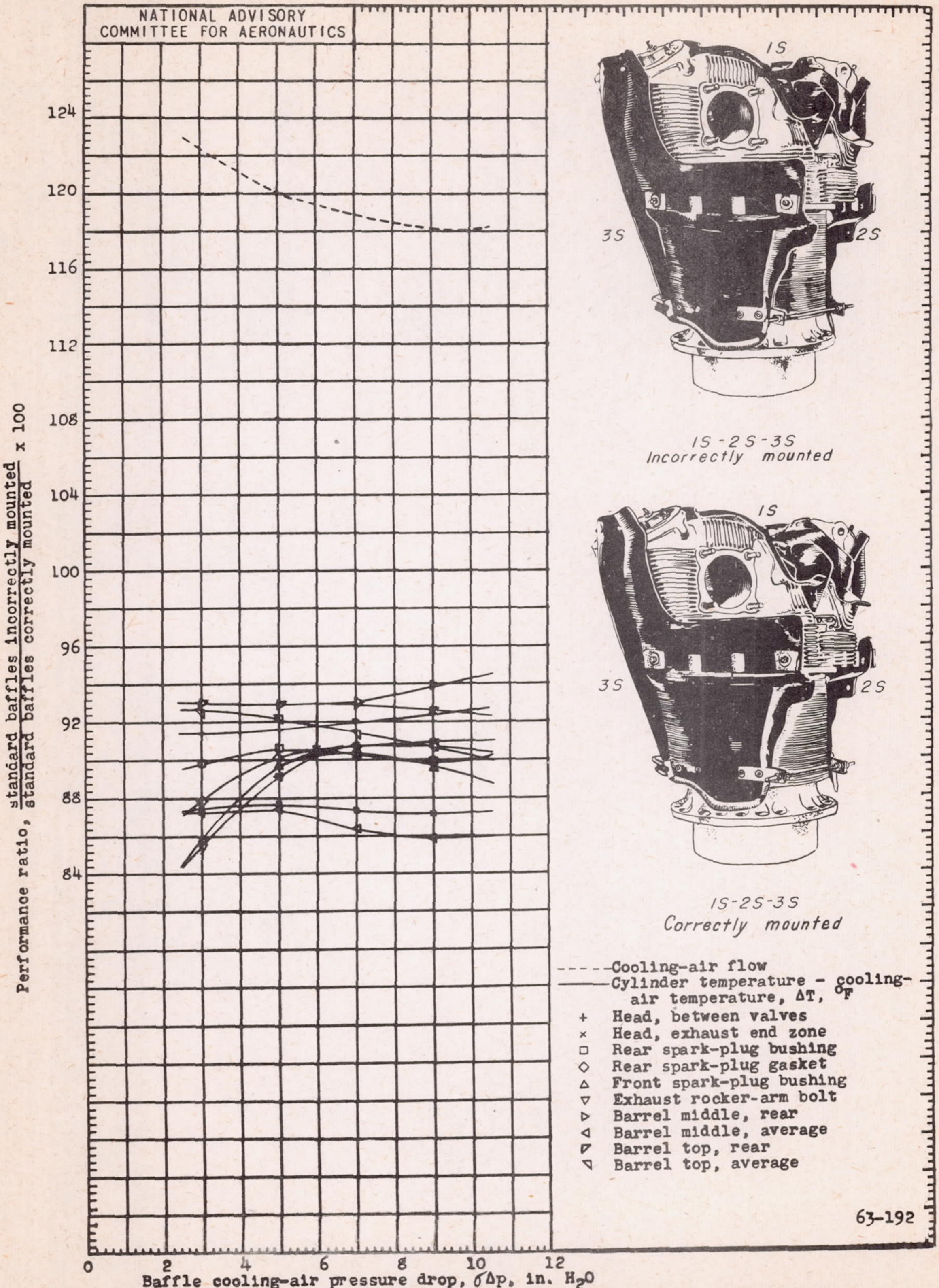


Figure 18. - Comparison of standard baffles 1S-2S-3S incorrectly mounted with the same baffles correctly mounted on a Wright 1820 G200 cylinder in single-cylinder tests. Indicated horsepower, 66; engine speed, 2000 rpm; manifold pressure, 31 inches of mercury absolute; fuel-air ratio, 0.083; cooling-air temperature, 100° F.

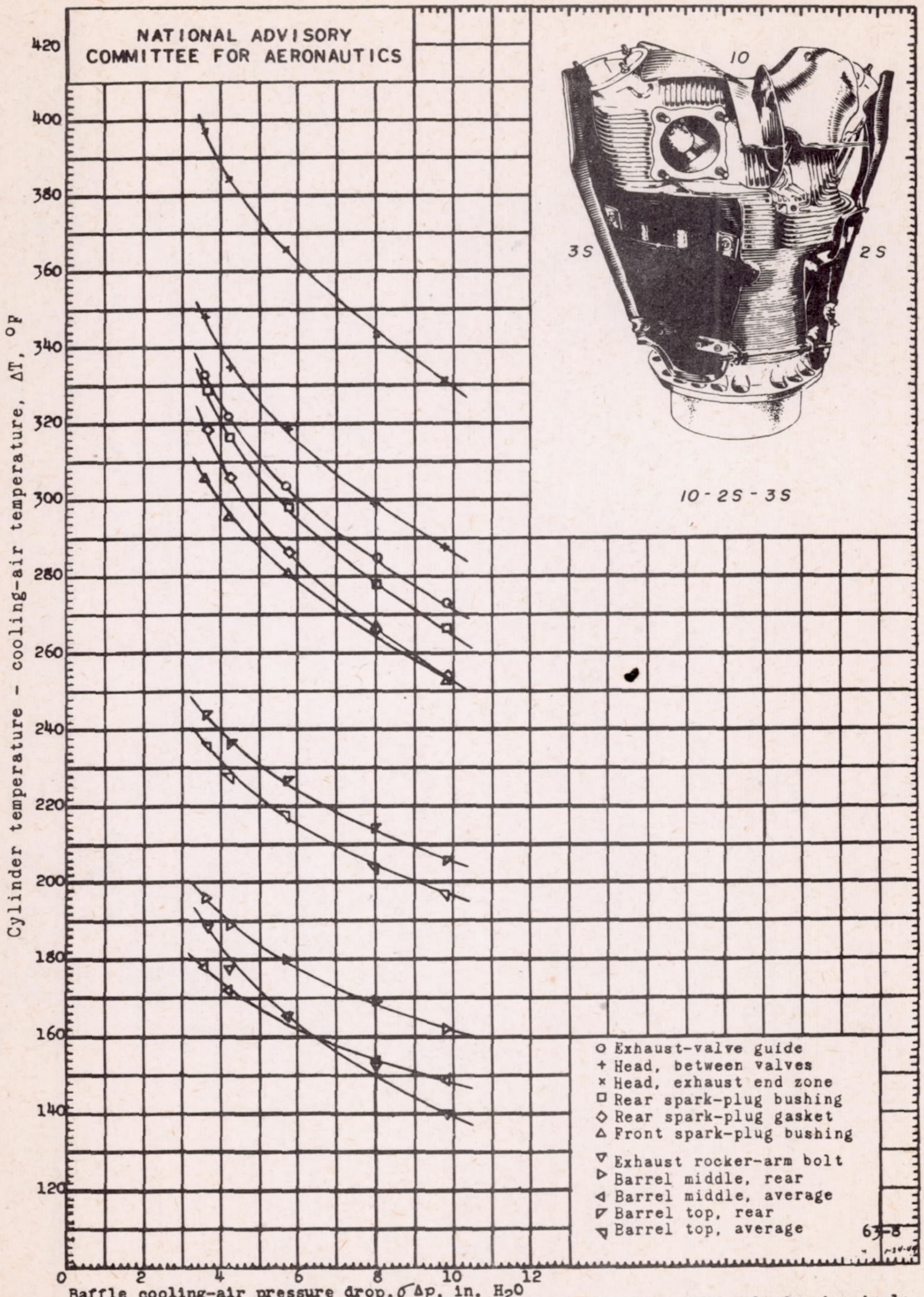


Figure 19. - Performance of special baffles 10-2S-3S on a Wright 1820 G200 cylinder in single-cylinder tests. Indicated horsepower, 66; engine speed, 2000 rpm; manifold pressure, 31 inches of mercury absolute; fuel-air ratio, 0.083; cooling-air temperature, 100° F.

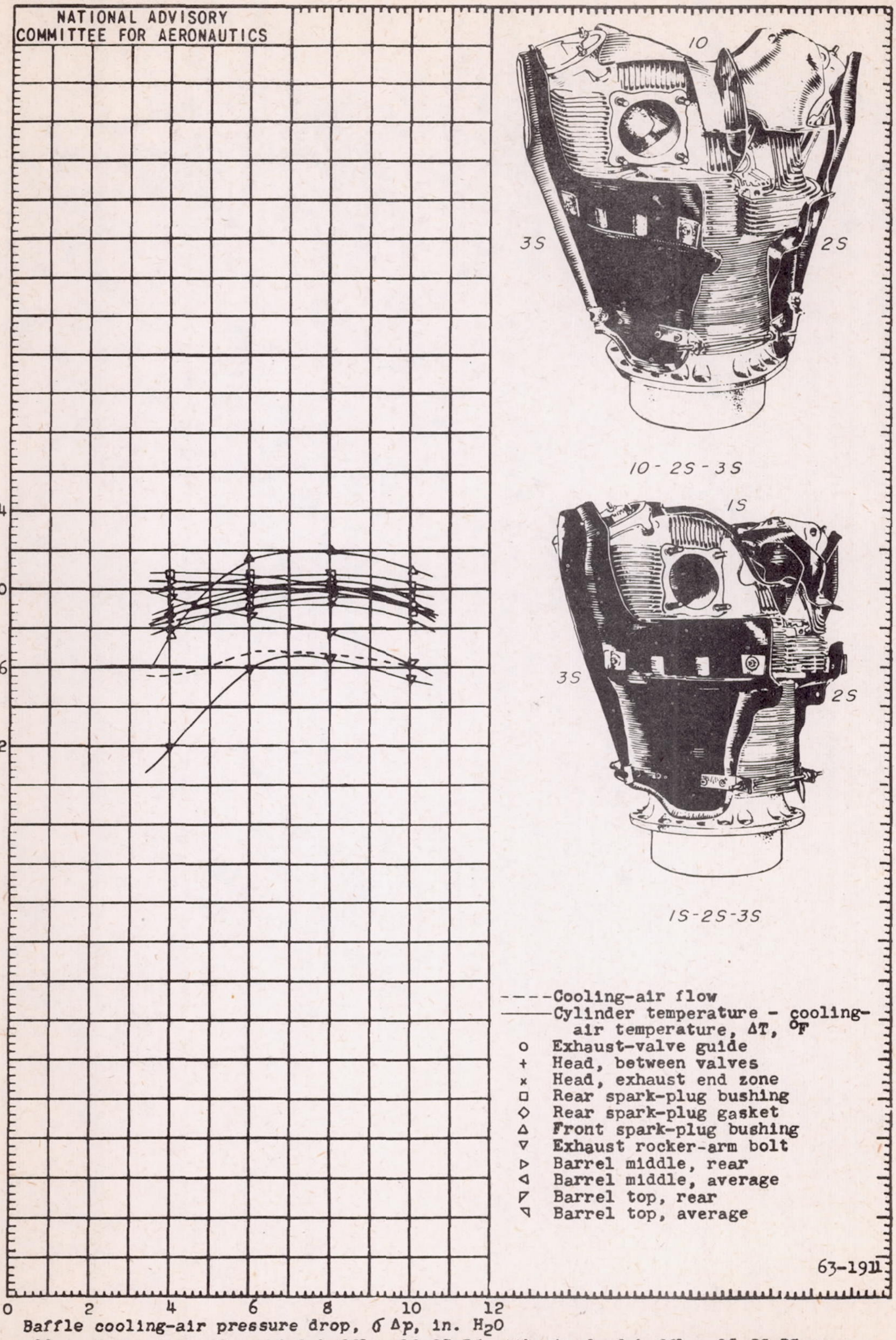


Figure 20. - Comparison of special baffles 10-2S-3S with standard baffles 1S-2S-3S on a Wright 1820 G200 cylinder in single-cylinder tests. Indicated horsepower, 66; engine speed, 2000 rpm; manifold pressure, 31 inches of mercury absolute; fuel-air ratio, 0.083; cooling-air temperature, 100° F.

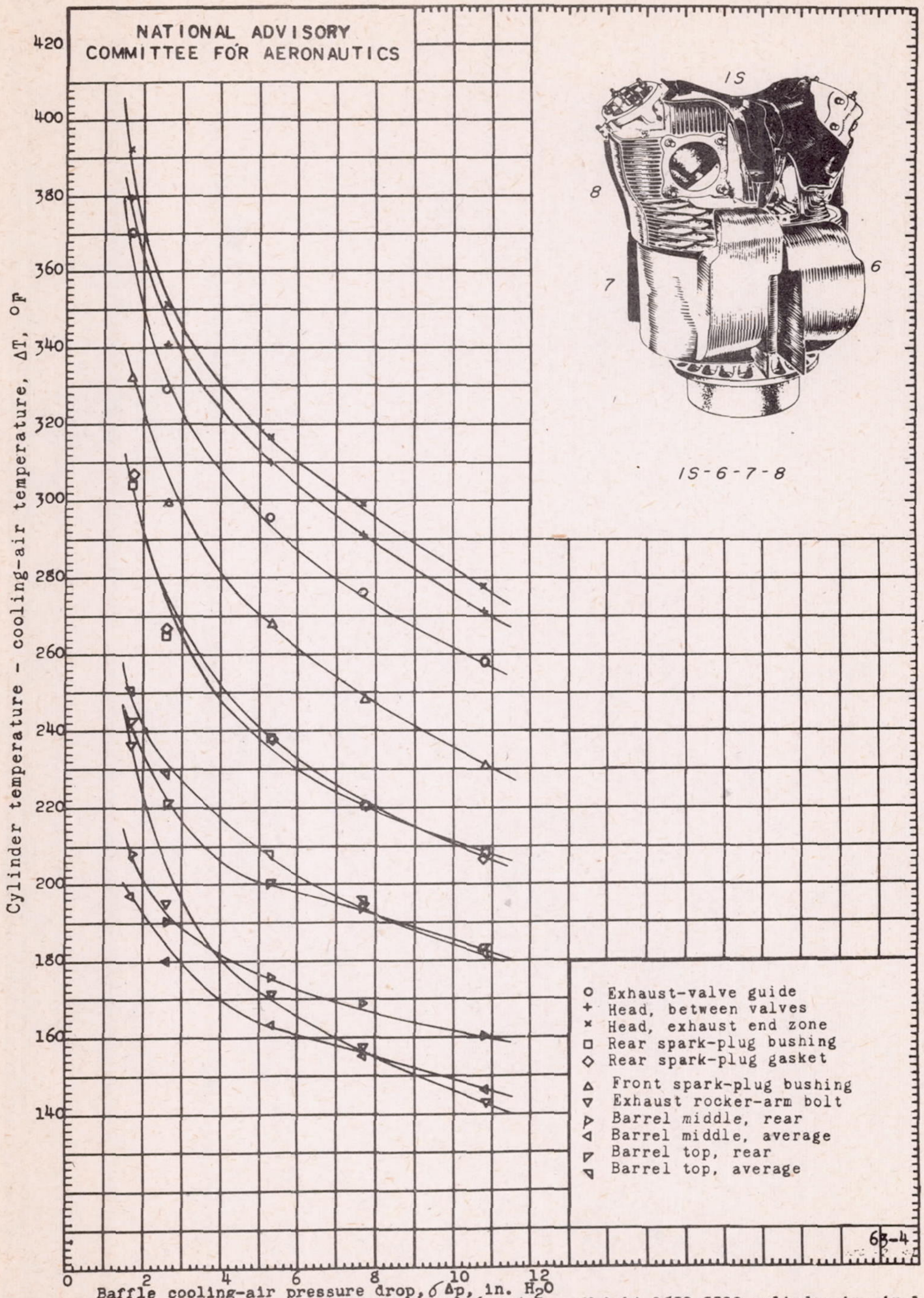


Figure 21. - Performance of special baffles 1S-6-7-8 on a Wright 1820 G200 cylinder in single-cylinder tests. Indicated horsepower, 66; engine speed, 2000 rpm; manifold pressure, 31 inches of mercury absolute; fuel-air ratio, 0.083; cooling-air temperature, 100° F.

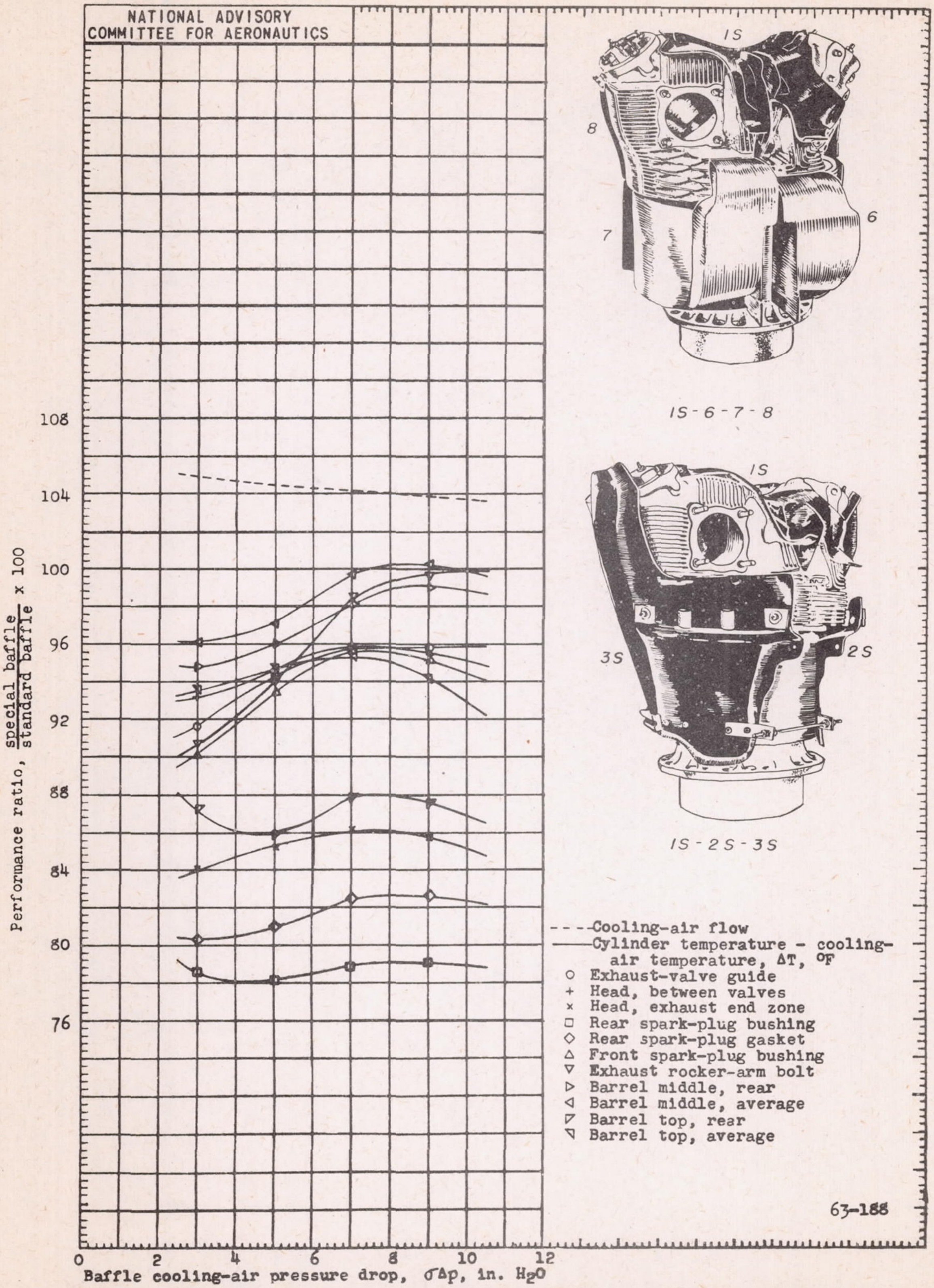


Figure 22. - Comparison of special baffles 1S-6-7-8 with standard baffles 1S-2S-3S on a Wright 1820 G200 cylinder in single-cylinder tests. Indicated horsepower, 66; engine speed, 2000 rpm; manifold pressure, 31 inches of mercury absolute; fuel-air ratio, 0.083; cooling-air temperature, 100° F.

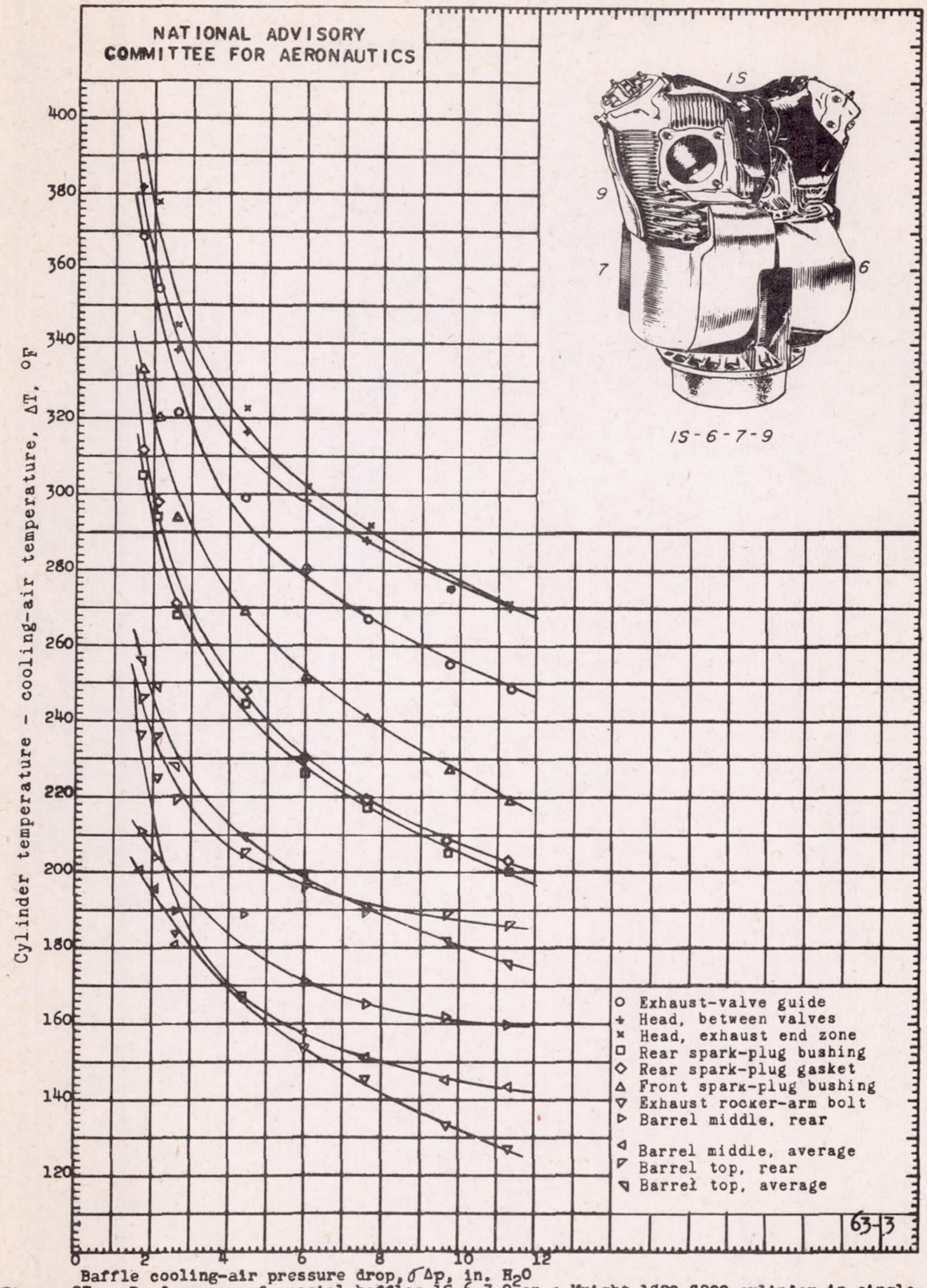


Figure 23. - Performance of special baffles 1S-6-7-9 on a Wright 1820 G200 cylinder in single-cylinder tests. Indicated horsepower, 66; engine speed, 2000 rpm; manifold pressure, 31 inches of mercury absolute; fuel-air ratio, 0.083; cooling-air temperature, 100° F.

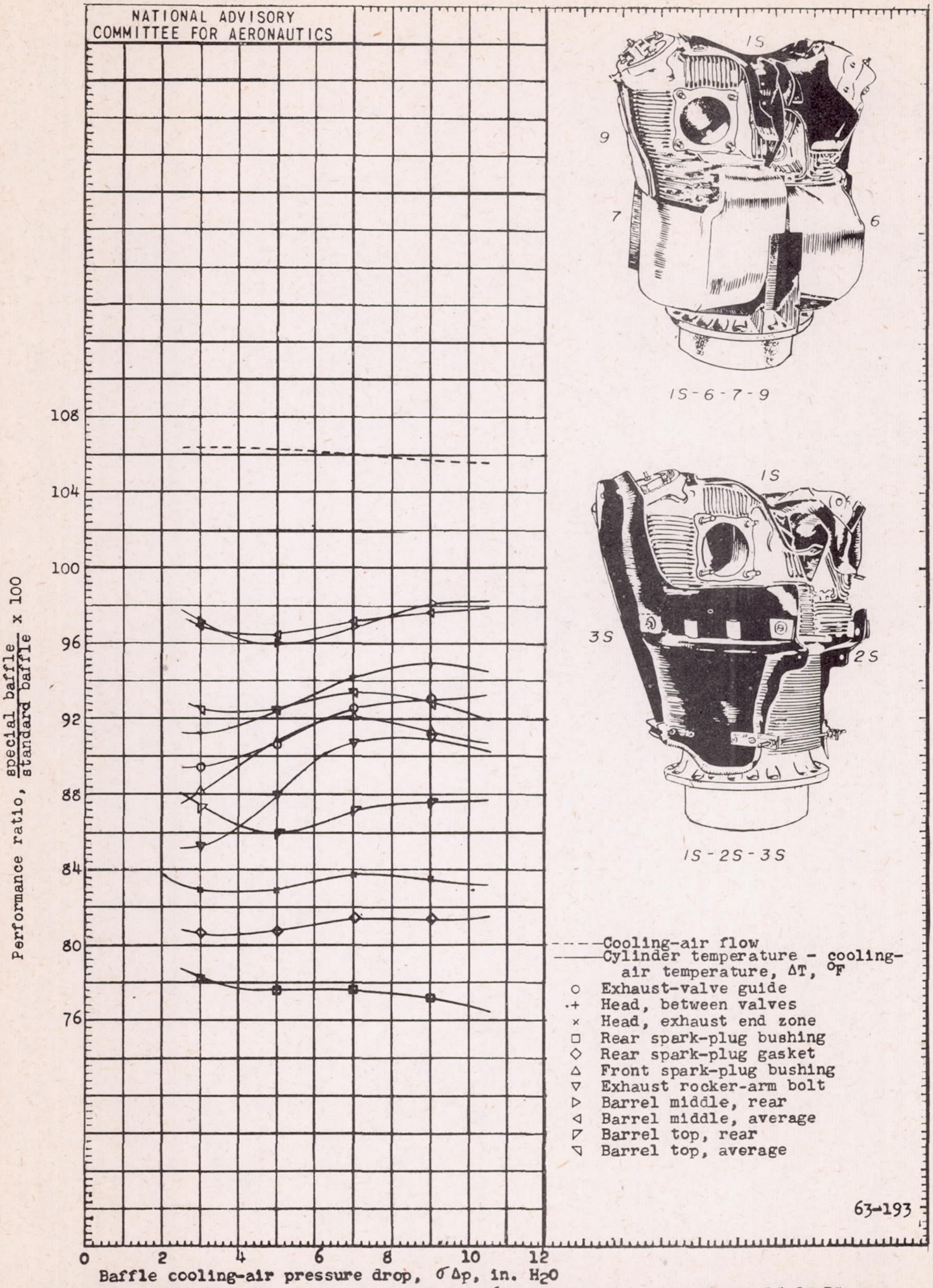


Figure 24. - Comparison of special baffles 1S-6-7-9 with standard baffles 1S-2S-3S on a Wright 1820 G200 cylinder in single-cylinder tests. Indicated horsepower, 66; engine speed, 2000 rpm; manifold pressure, 31 inches of mercury absolute; fuel-air ratio, 0.083; cooling-air temperature, 100° F

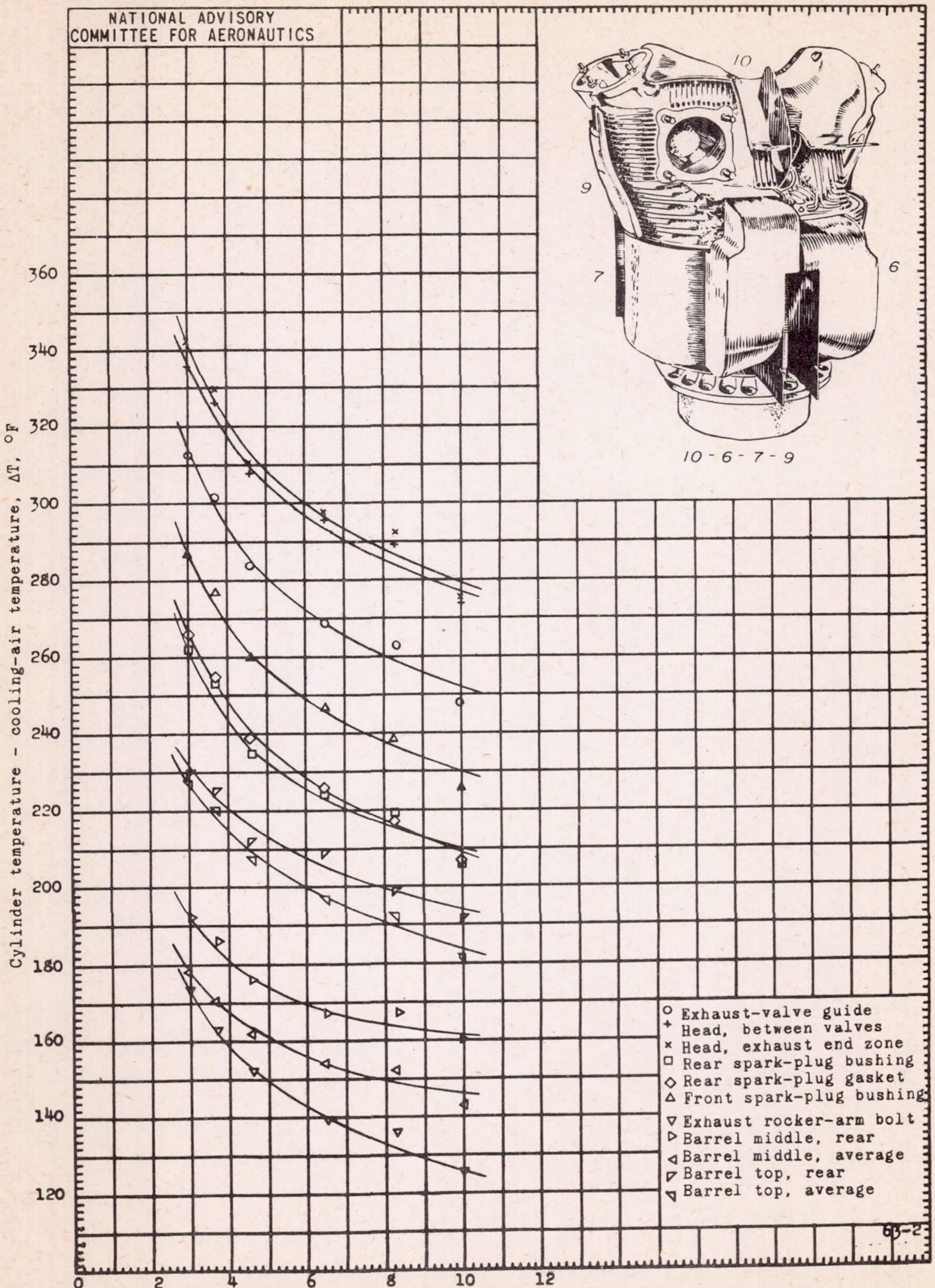


Figure 25. - Performance of special baffles 10-6-7-9 on a Wright 1820 G200 cylinder in single-cylinder tests. Indicated horsepower, 66; engine speed, 2000 rpm; manifold pressure, 31 inches of mercury absolute; fuel-air ratio, 0.083; cooling-air temperature, 100° F.

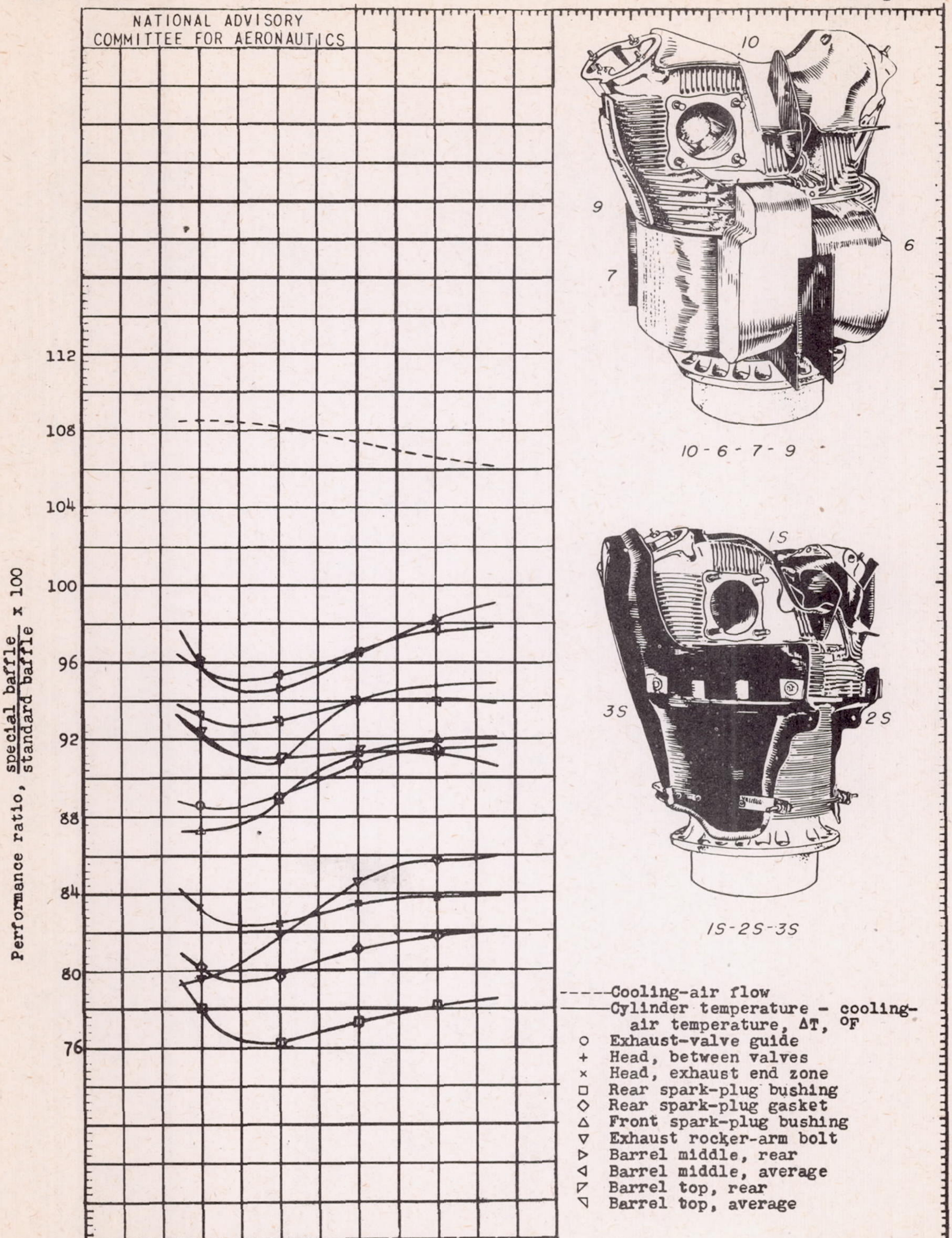


Figure 26. - Comparison of special baffles 10-6-7-9 with standard baffles 1S-2S-3S on a Wright 1820 G200 cylinder in single-cylinder tests. Indicated horsepower, 66; engine speed, 2000 rpm; manifold pressure, 31 inches of mercury absolute; fuel-air ratio, 0.083; cooling-air temperature, 100° F.

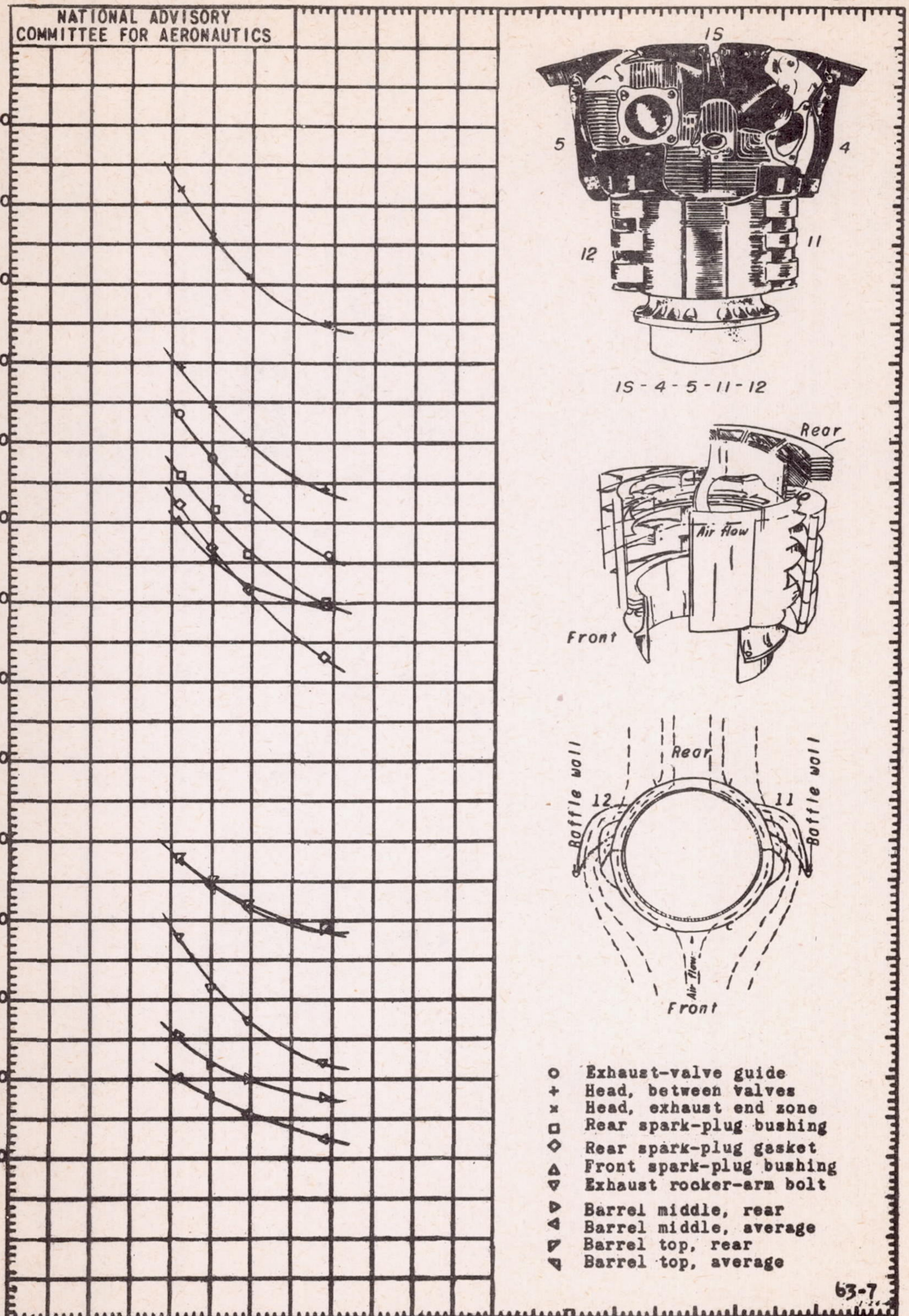


Figure 27. - Performance of special baffles 1S-4-5-11-12 on a Wright 1820 G200 cylinder in single-cylinder tests. Indicated horsepower, 66; engine speed, 2000 rpm; manifold pressure, 31 inches of mercury absolute; fuel-air ratio, 0.083; cooling-air temperature, 100° F.

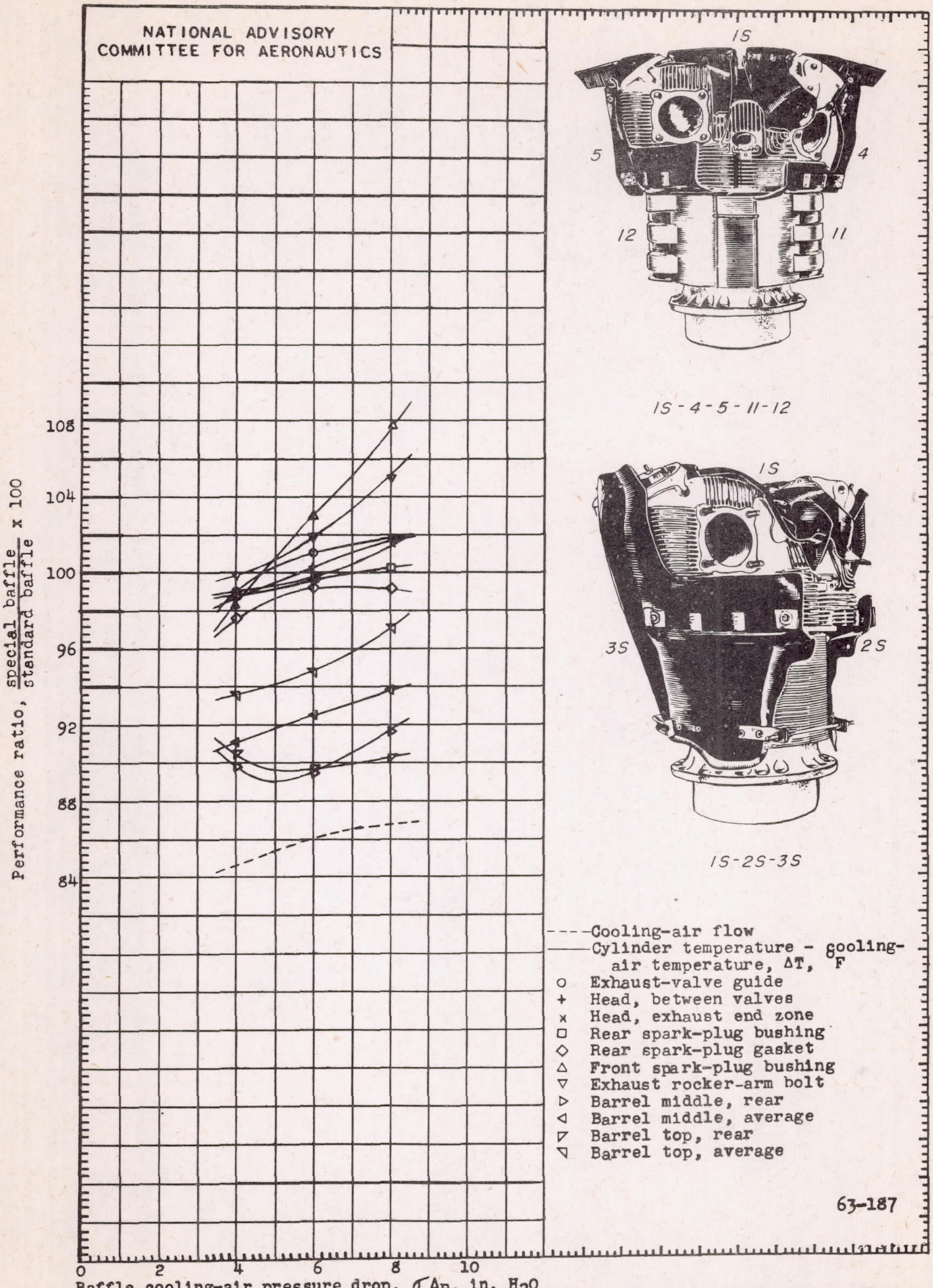


Figure 28. - Comparison of special baffles 1S-4-5-11-12 with standard baffles 1S-2S-3S on a Wright 1820 G200 cylinder in single-cylinder tests. Indicated horsepower, 66; engine speed, 2000 rpm; manifold pressure, 31 inches of mercury absolute; fuel-air ratio, 0.083; cooling-air temperature, 100° F.

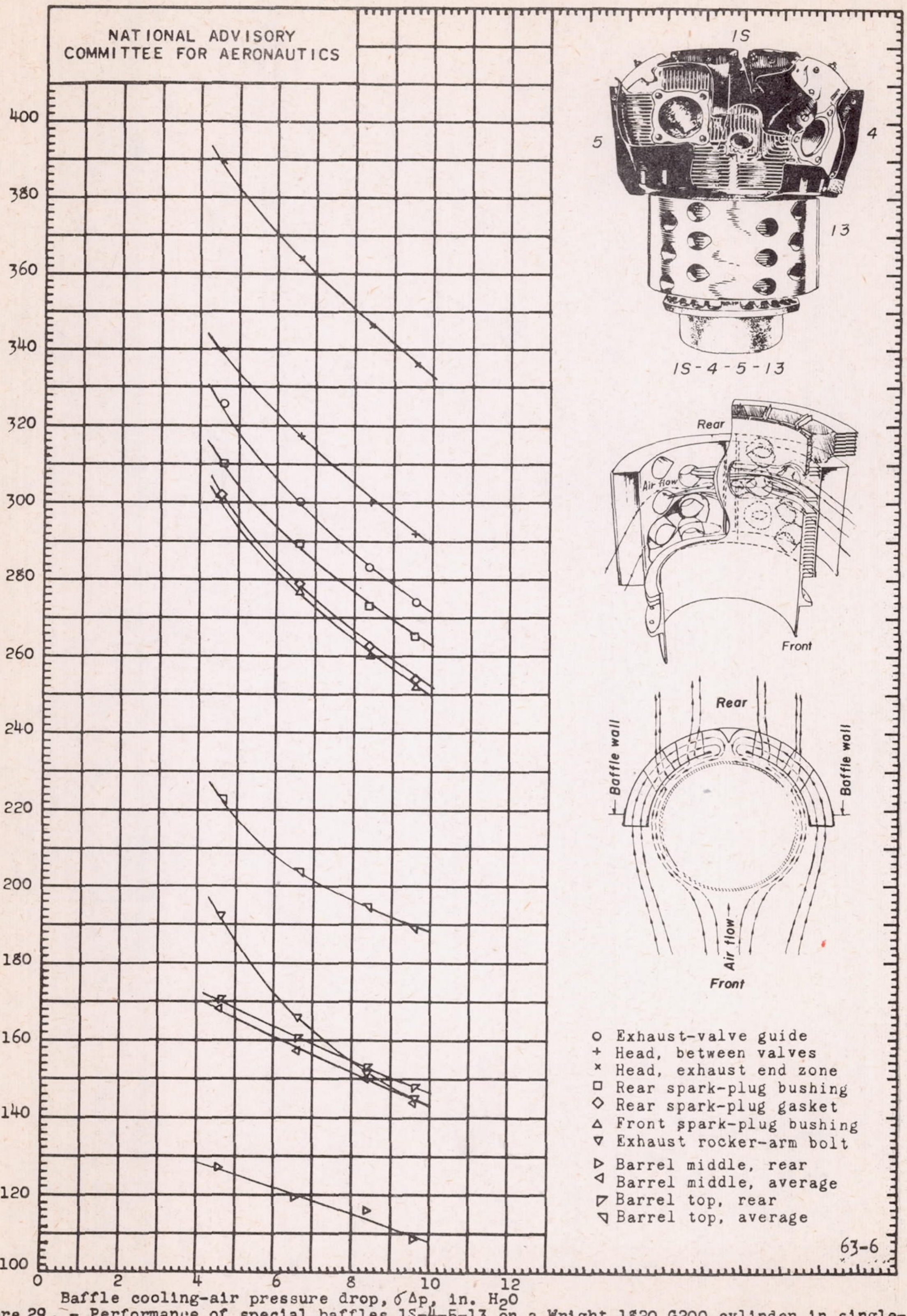


Figure 29. - Performance of special baffles 1S-4-5-13 on a Wright 1820 G200 cylinder in single-cylinder tests. Indicated horsepower, 66; engine speed, 2000 rpm; manifold pressure, 31 inches of mercury absolute; fuel-air ratio, 0.083; cooling-air temperature, 100° F.

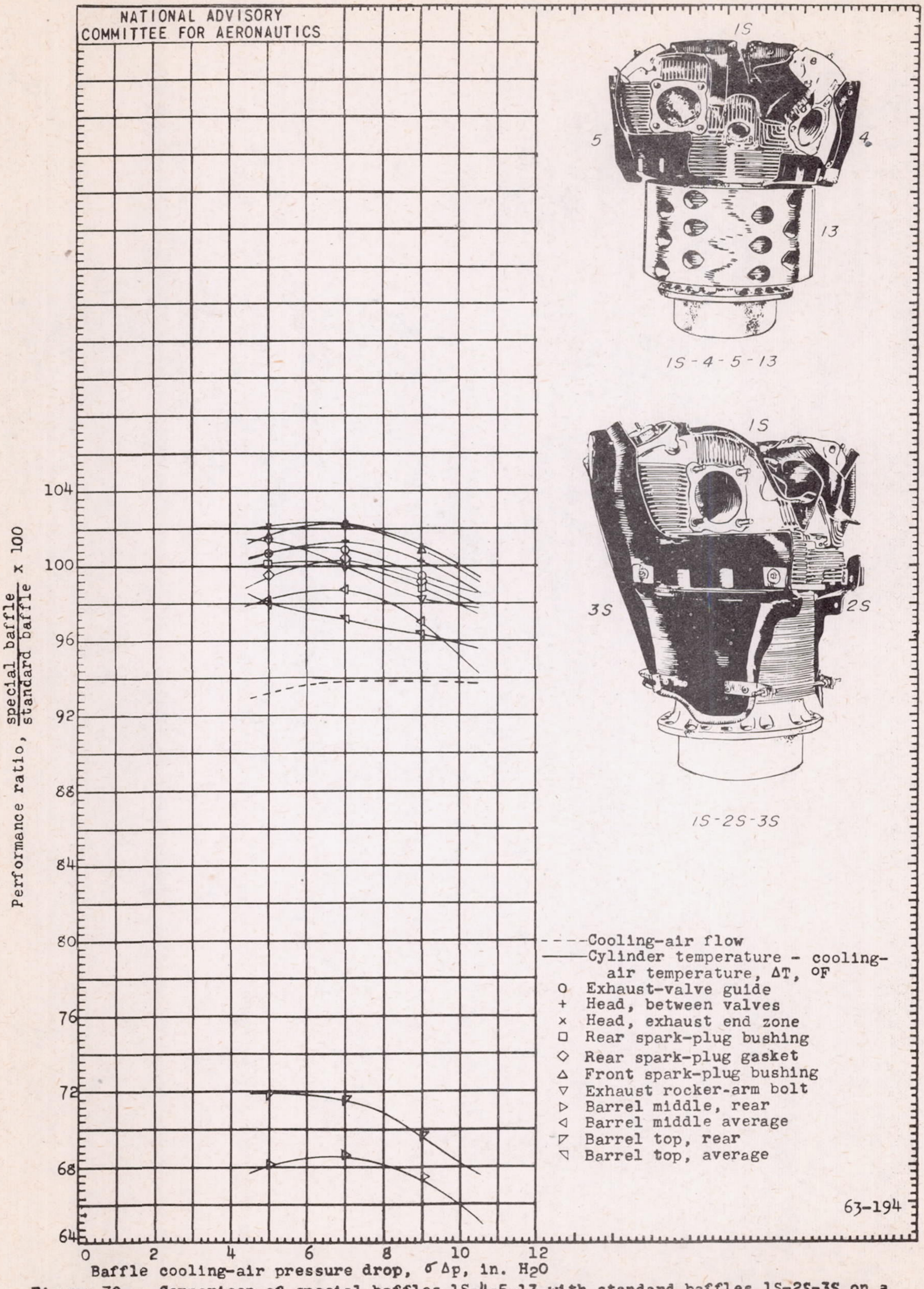


Figure 30. - Comparison of special baffles 1S-4-5-13 with standard baffles 1S-2S-3S on a Wright 1820 G200 cylinder in single-cylinder tests. Indicated horsepower, 66; engine speed, 2000 rpm; manifold pressure, 31 inches of mercury absolute; fuel-air ratio, 0.083; cooling-air temperature, 100° F.

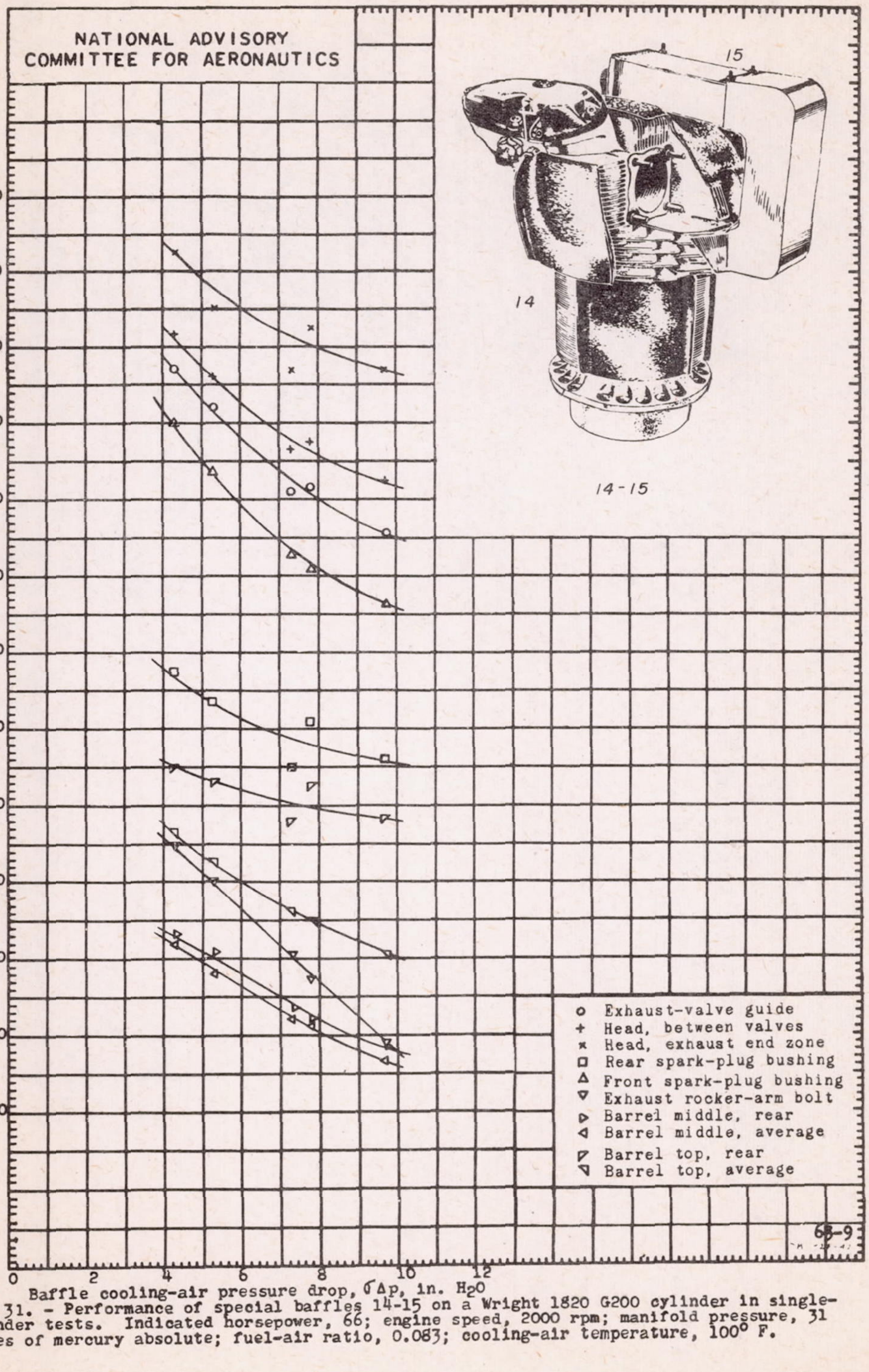


Figure 31. - Performance of special baffles 14-15 on a Wright 1820 G200 cylinder in single-cylinder tests. Indicated horsepower, 66; engine speed, 2000 rpm; manifold pressure, 31 inches of mercury absolute; fuel-air ratio, 0.083; cooling-air temperature, 100° F.

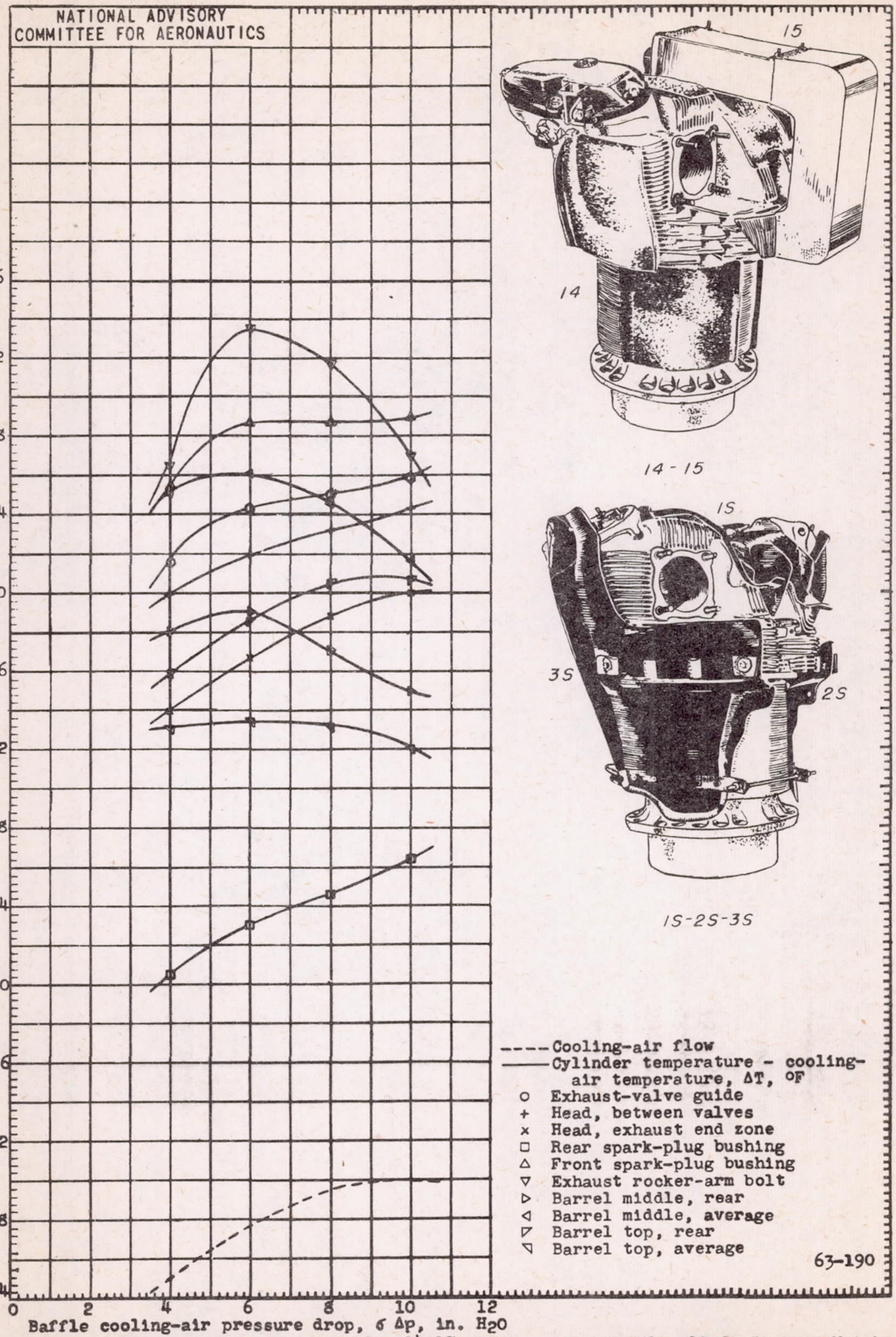


Figure 32. - Comparison of special baffles 14-15 with standard baffles 1S-2S-3S on a Wright 1820 G200 cylinder in single-cylinder tests. Indicated horsepower, 66; engine speed, 2000 rpm; manifold pressure, 31 inches of mercury absolute; fuel-air ratio, 0.083; cooling-air temperature, 100° F.

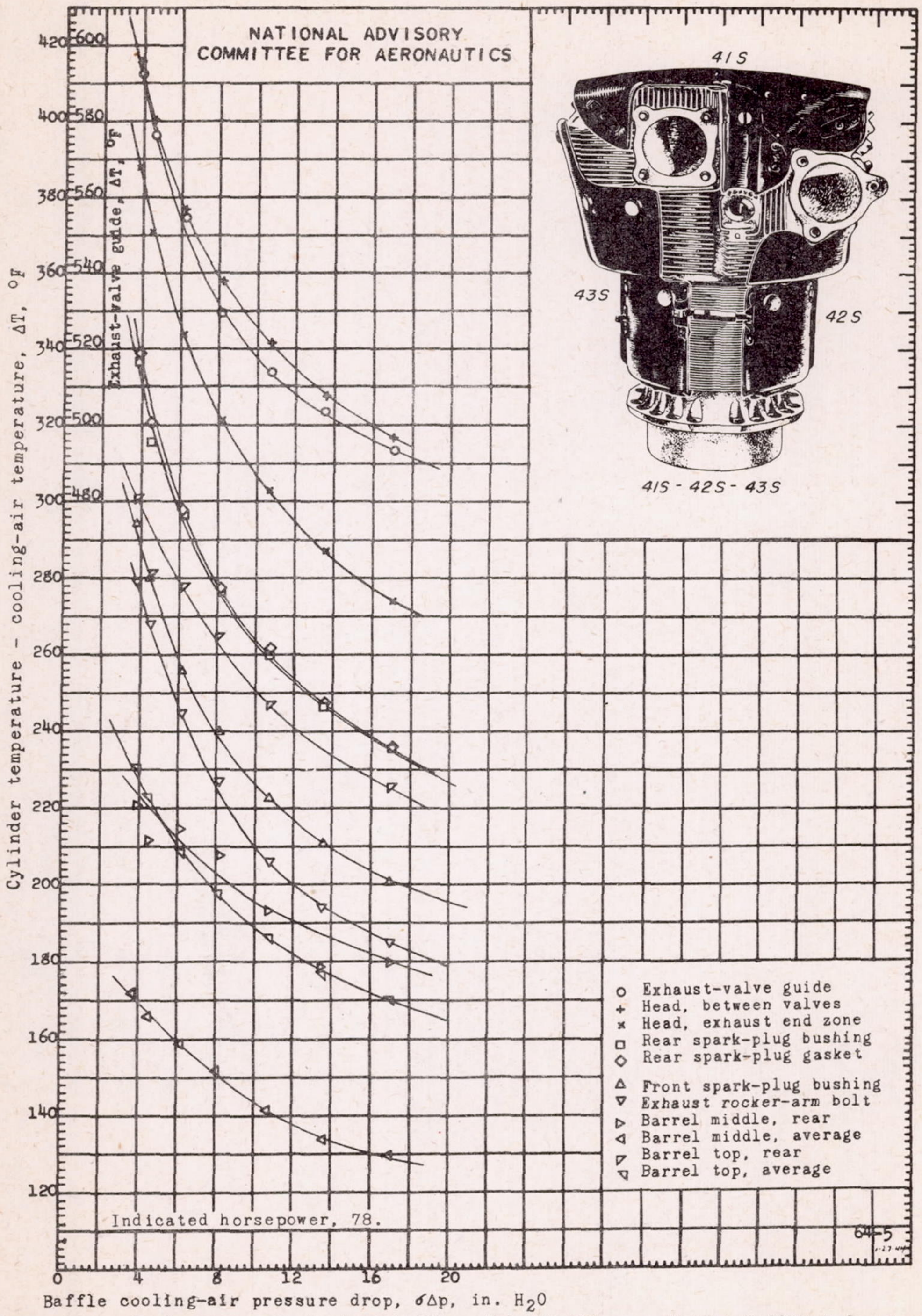


Figure 33. - Performance of standard baffles 41S-42S-43S on a Wright R-2600-8 front-row cylinder in single-cylinder tests at an indicated horsepower of 78. Engine speed, 2100 rpm; manifold pressure, 31 inches of mercury absolute; fuel-air ratio, 0.075; cooling-air temperature, 100° F.

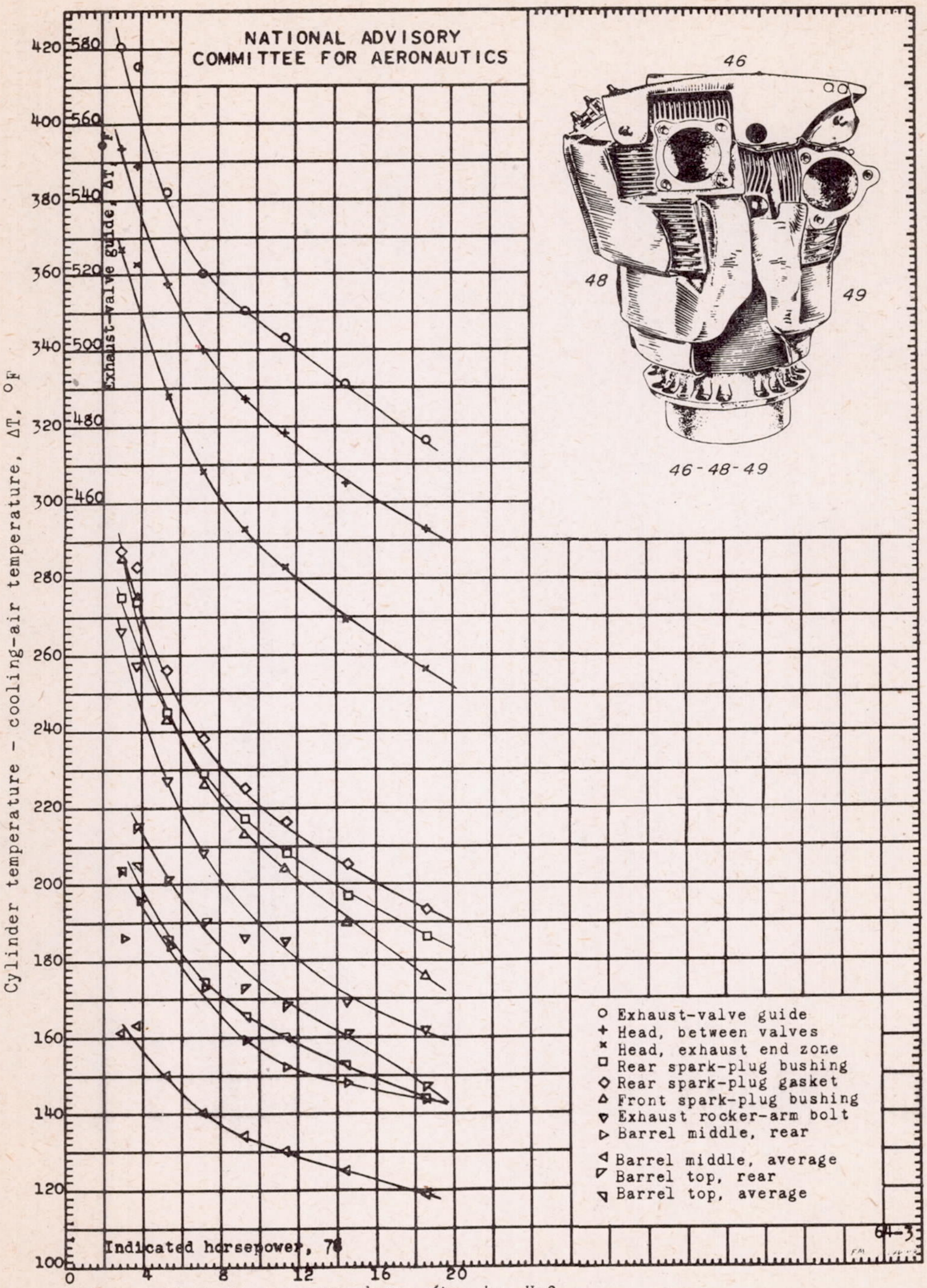


Figure 34. - Performance of special baffles 46-48-49 on a Wright R-2600-8 front-row cylinder in single-cylinder tests at an indicated horsepower of 78. Engine speed, 2100 rpm; manifold pressure, 31 inches of mercury absolute; fuel-air ratio, 0.075; cooling-air temperature, 100° F.

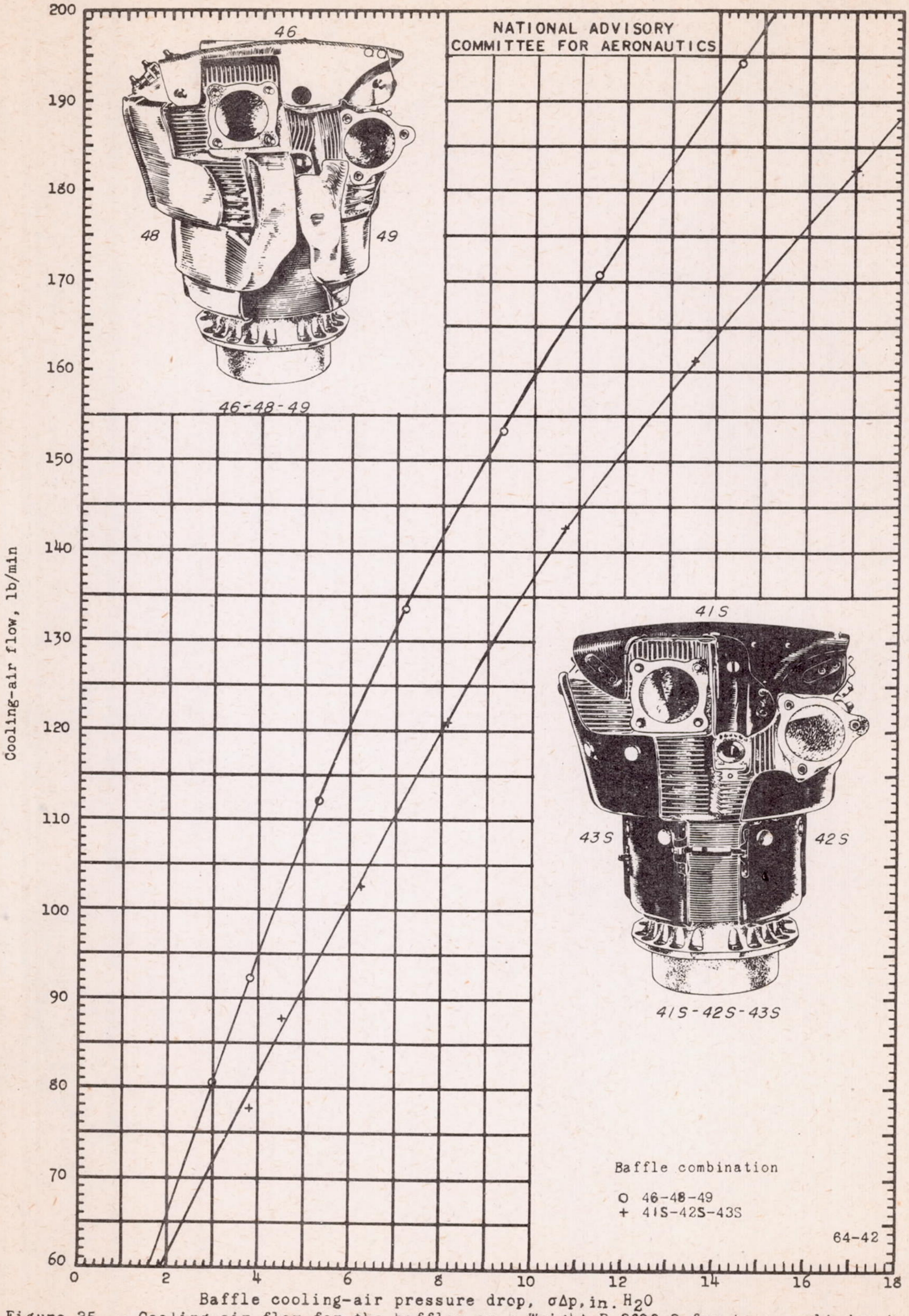


Figure 35. - Cooling-air flow for the baffles on a Wright R-2600-8 front-row cylinder in single-cylinder tests at an indicated horsepower of 78. Engine speed, 2100 rpm; manifold pressure, 31 inches of mercury absolute; fuel-air ratio, 0.075; cooling-air temperature, 100° F.

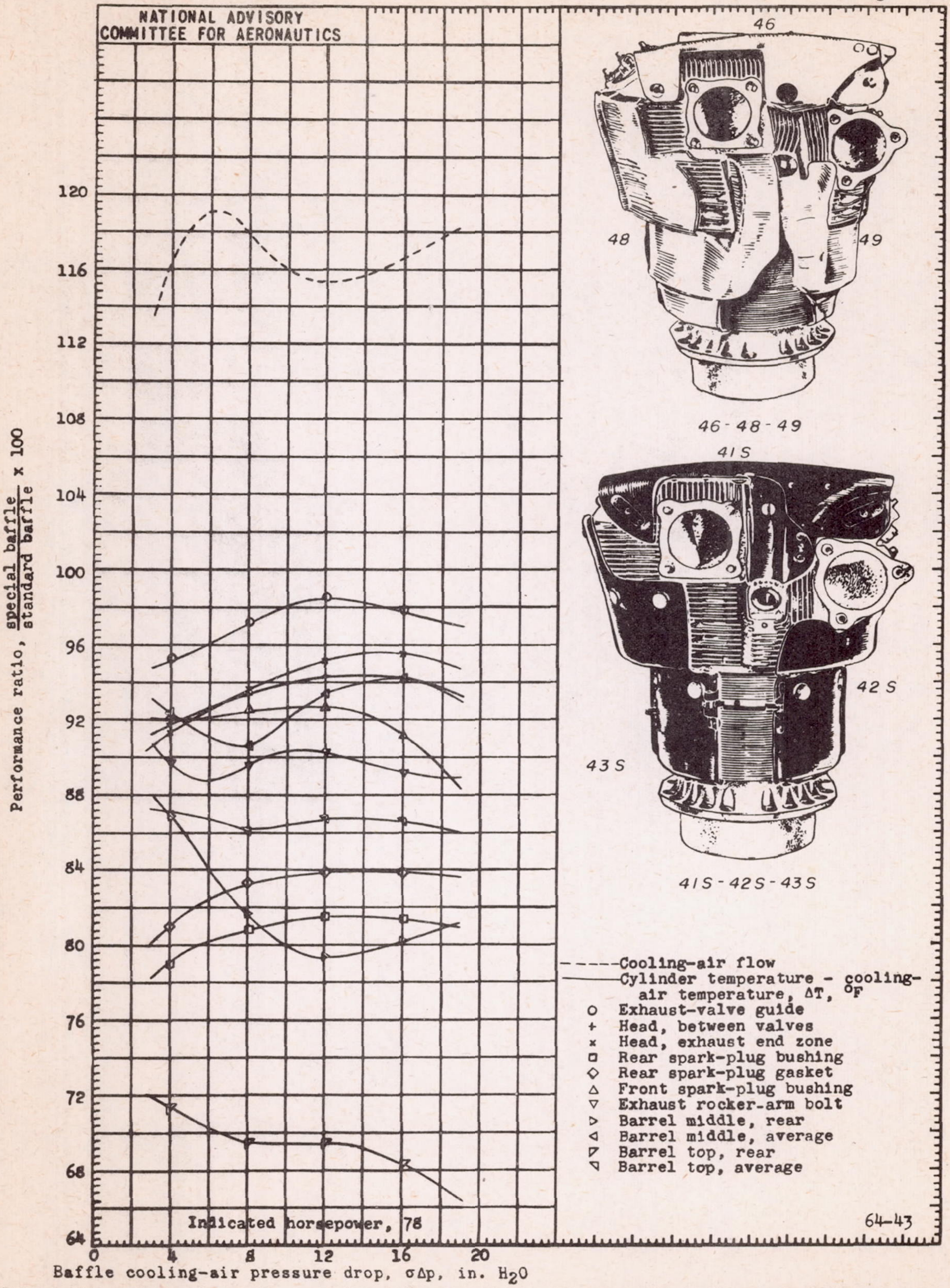


Figure 36. - Comparison of special baffles 46-48-49 with standard baffles 41S-42S-43S on a Wright R-2600-8 front-row cylinder in single-cylinder tests at an indicated horsepower of 78. Engine speed, 2100 rpm; manifold pressure, 31 inches of mercury absolute; fuel-air ratio, 0.075; cooling-air temperature, 100° F.

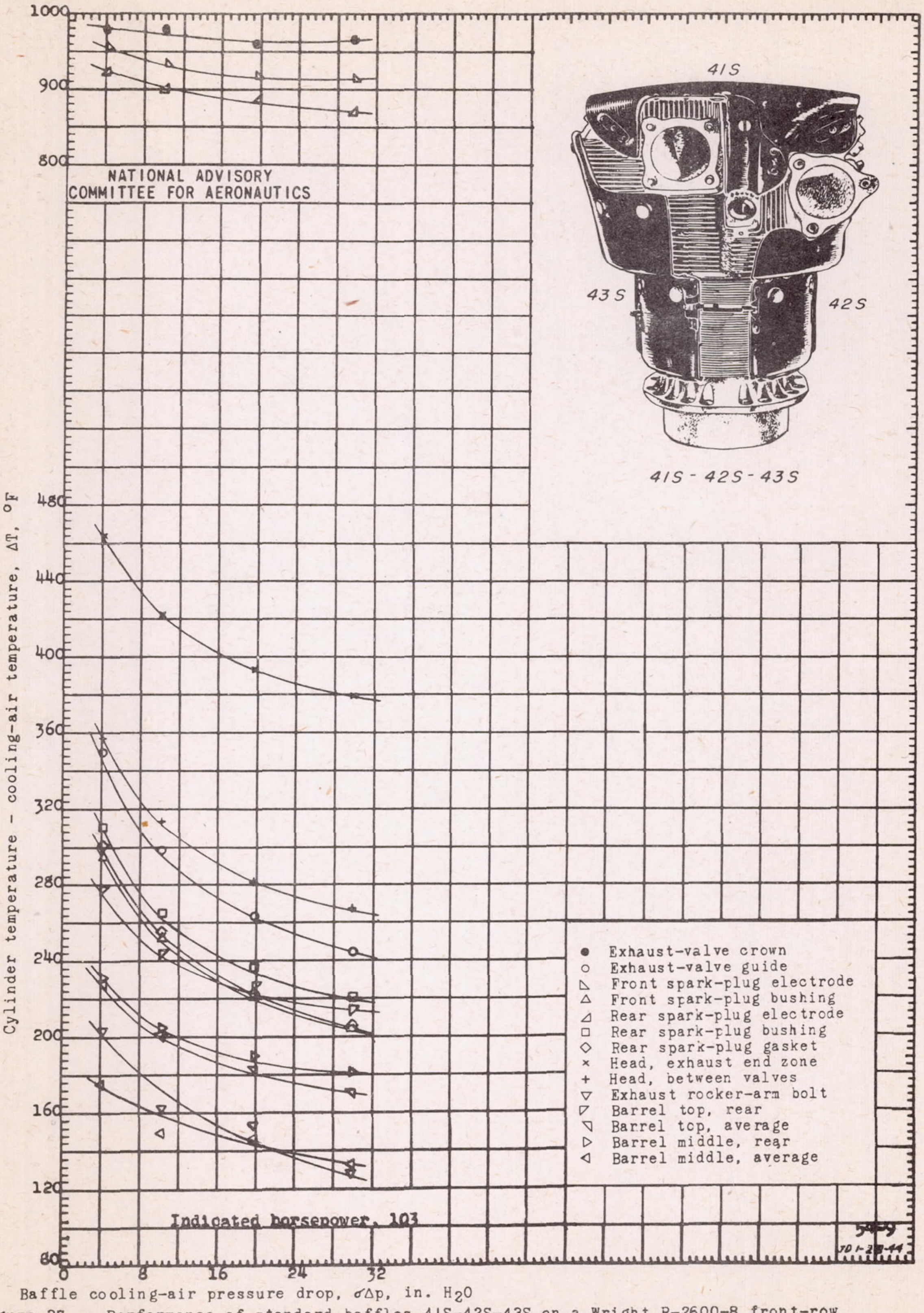


Figure 37. - Performance of standard baffles 41S-42S-43S on a Wright R-2600-8 front-row cylinder in single-cylinder tests at an indicated horsepower of 103. Engine speed, 2100 rpm; manifold pressure, 38 inches of mercury absolute; fuel-air ratio, 0.10; cooling-air temperature, 90° F.

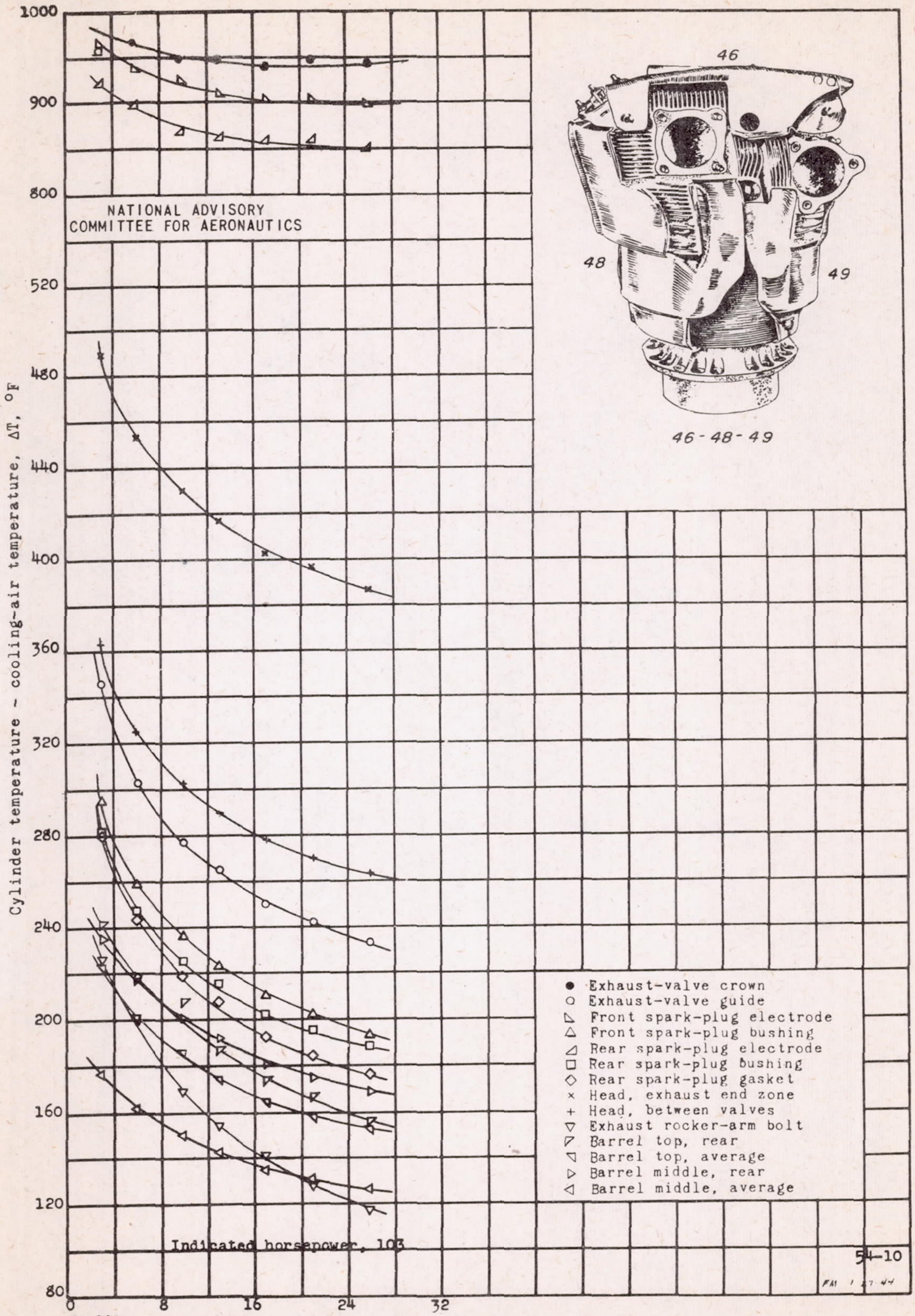
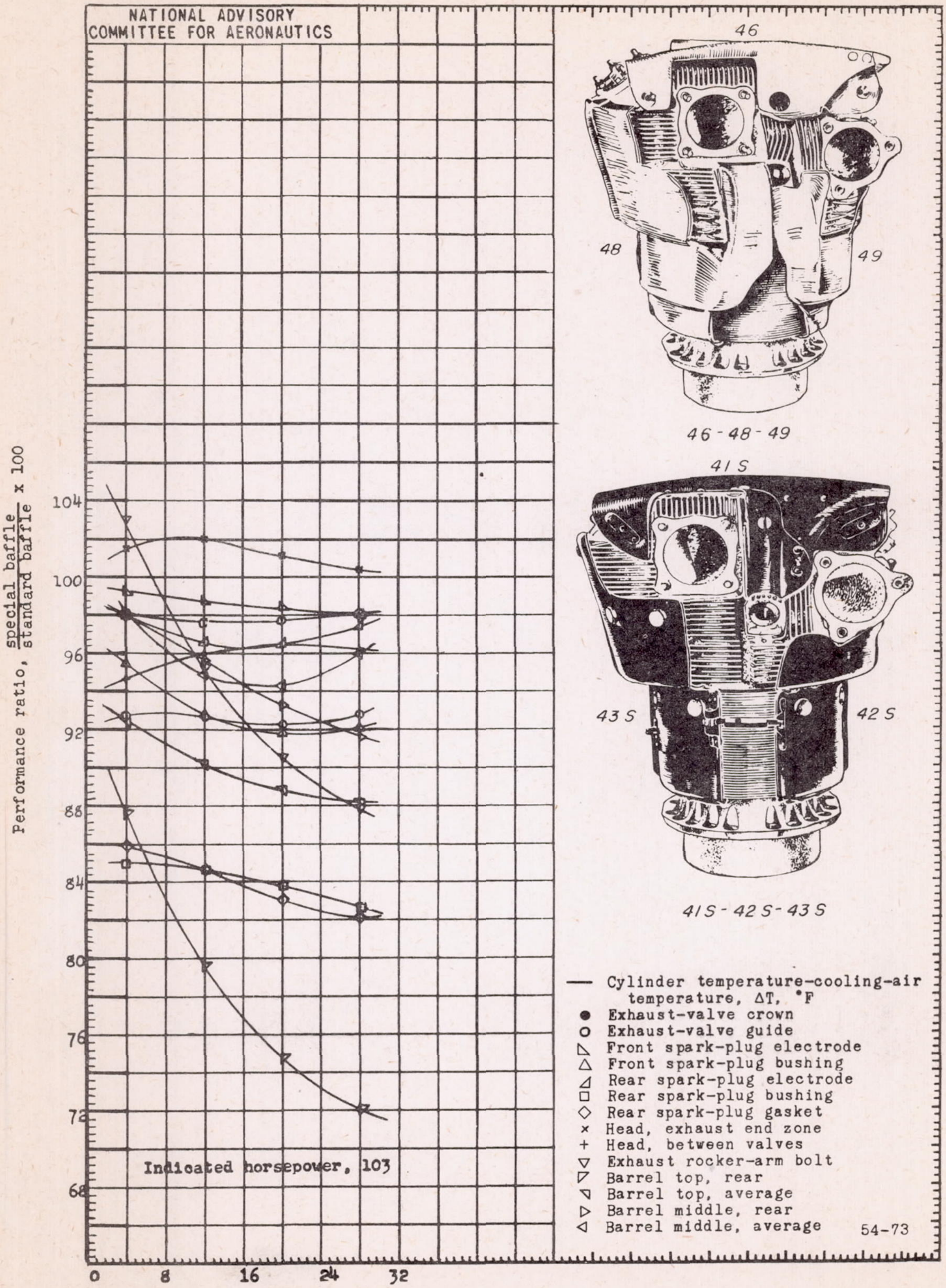


Figure 38. - Performance of special baffles 46-48-49 on a Wright R-2600-8 front-row cylinder in single-cylinder tests at an indicated horsepower of 103. Engine speed, 2100 rpm; manifold pressure, 38 inches of mercury absolute; fuel-air ratio, 0.10; cooling-air temperature, 90° F.



Baffle cooling-air pressure drop, $\sigma\Delta p$, in. H_2O

Figure 39. - Comparison of special baffles 46-48-49 with standard baffles 41S-42S-43S on a Wright R-2600-8 front-row cylinder in single-cylinder tests at an indicated horsepower of 103. Engine speed, 2100 rpm; manifold pressure, 38 inches of mercury absolute; fuel-air ratio, 0.10; cooling-air temperature, 90° F.

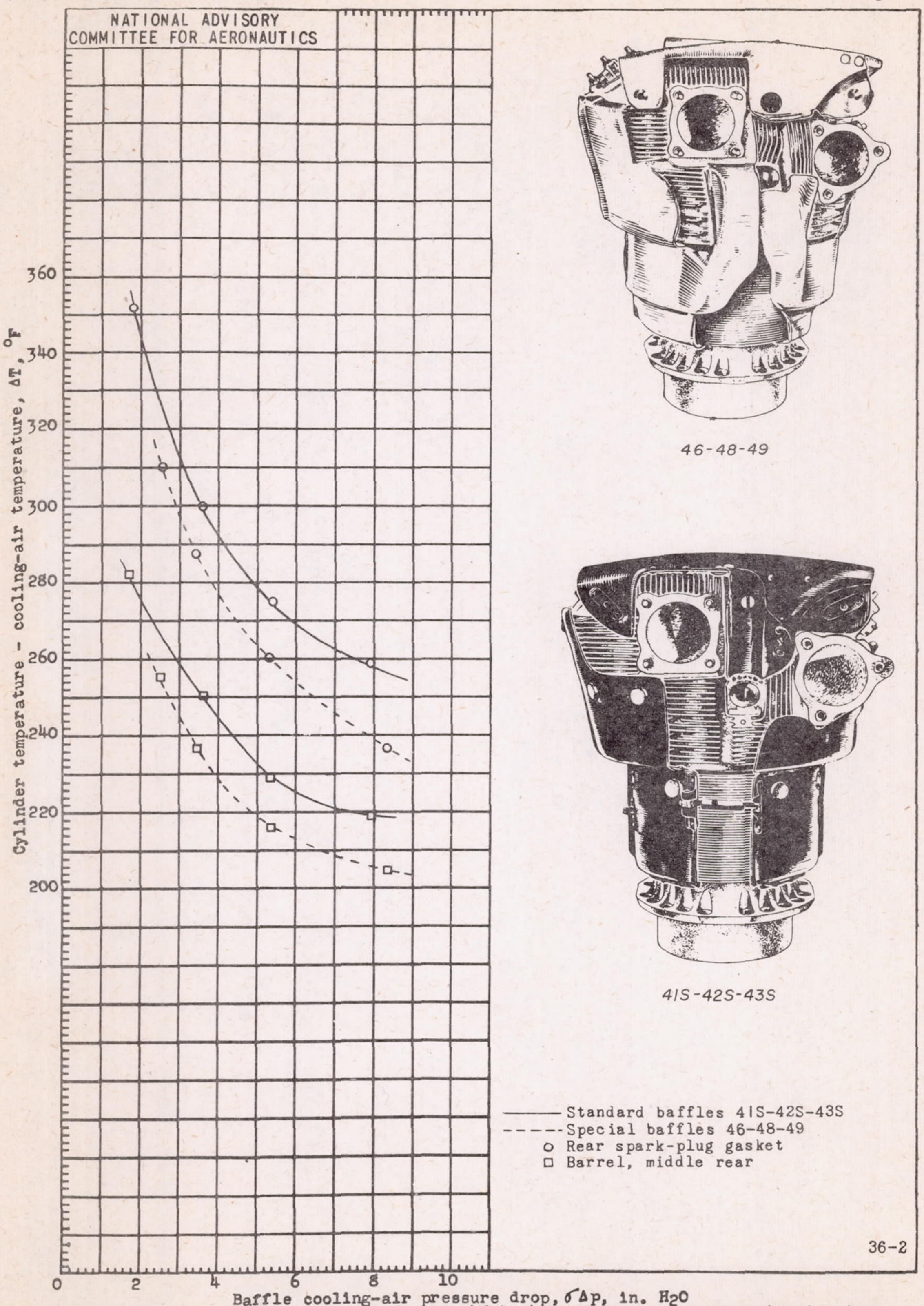


Figure 40. - Comparison of special baffles 46-48-49 and standard baffles 41S-42S-43S on cylinder 2 of the front row of a Wright R-2600-8 engine in multicylinder engine tests. Brake horsepower, 925; engine speed, 2100 rpm; manifold pressure, 31 inches of mercury absolute; fuel-air ratio, 0.075.